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Contents

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Papers will be accepted in the following categories:

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Benth., *Fl. Austral.* 4: (1868) 111.

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IRENEPHARSUS, A NEW GENUS IN BRASSICACEAE IN AUSTRALIA

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Abstract

The new genus *Irenepharsus* with three species is recognised: *I. phasmatodes* Hewson, *I. magicus* Hewson and *I. trypherus* Hewson. The genus is placed in tribe *Sisymbrieae*, subtribe *Arabidopsidinae* together with several other Australian endemic genera. An analysis of generic delimitation is presented.

IRENEPHARSUS Hewson

Irenepharsus Hewson, Fl. Aust. 8: 391, 349 (1982).
Type: *Irenepharsus phasmatodes* Hewson.

Annual herbs, tap-rooted, sparingly to profusely branched, erect. *Leaves* in basal rosette and cauline, attenuate to petiolate, obtuse to acute, sparsely pubescent with sessile to shortly stipitate branched hairs. *Inflorescence* an ebracteate raceme elongating from a few-flowered terminal corymb; flowering pedicels slender, half spreading; buds spherical. *Calyx* open; sepals sub-equal, ovate to obovate, green to purple-pigmented with narrow hyaline margin. *Petals* to twice as long as sepals, spreading, white; blade broadly ovate, contracting sharply into narrow claw approximately one third of petal length. *Stamens* 6, the 4 median ones erect to slightly spreading, the 2 lateral ones ascending; filaments slightly dilated at base. *Nectariferous glands* apparently in a continuous ring outside median filaments and encircling the lateral filaments (not examined in vivo). *Pistil* not stipitate; ovary linear, terete, glabrous; ovules pendulous, 10-20 per loculus; style shortly cylindrical or indistinct; stigma capitate; fruiting pedicels not markedly expanding towards receptacle, erect to half-spreading. *Fruit* a siliqua, dehiscent, linear, terete; valves convex, glabrous, sometimes purple-pigmented, mid-vein fading above, somewhat delicate so that mature seeds can be seen, though not markedly constricted between seeds; stigma as wide or wider than style; septum translucent, folded around adjacent seed surface. *Seeds* uniseriate to sub-biseriate, 10-20 per loculus, oblong-ovoid, dark-brown reticulate, with or without half wing, mucose; cotyledons incumbent.

The generic name is derived from the Greek *Irene* (peace) and *pharseos* (piece).

Key to Species

1. Cauline leaves with entire margin, sparse, the upper ones linear; style 0.2-0.7 mm long. .... 1. *I. phasmatodes*

1: Cauline leaves with serrate or dentate margin, plentiful, the upper ones lanceolate; style 0.75-1.75 mm long.

2. Leaves with sparse pubescence; siliqua more than 1 mm wide; seeds with half-wing on cotyledon margin, mucose. .... 2. *I. magicus*

2: Leaves glabrous; siliqua up to 1 mm wide; seeds without wing, sticky (scarcely mucose) .... 3. *I. trypherus*

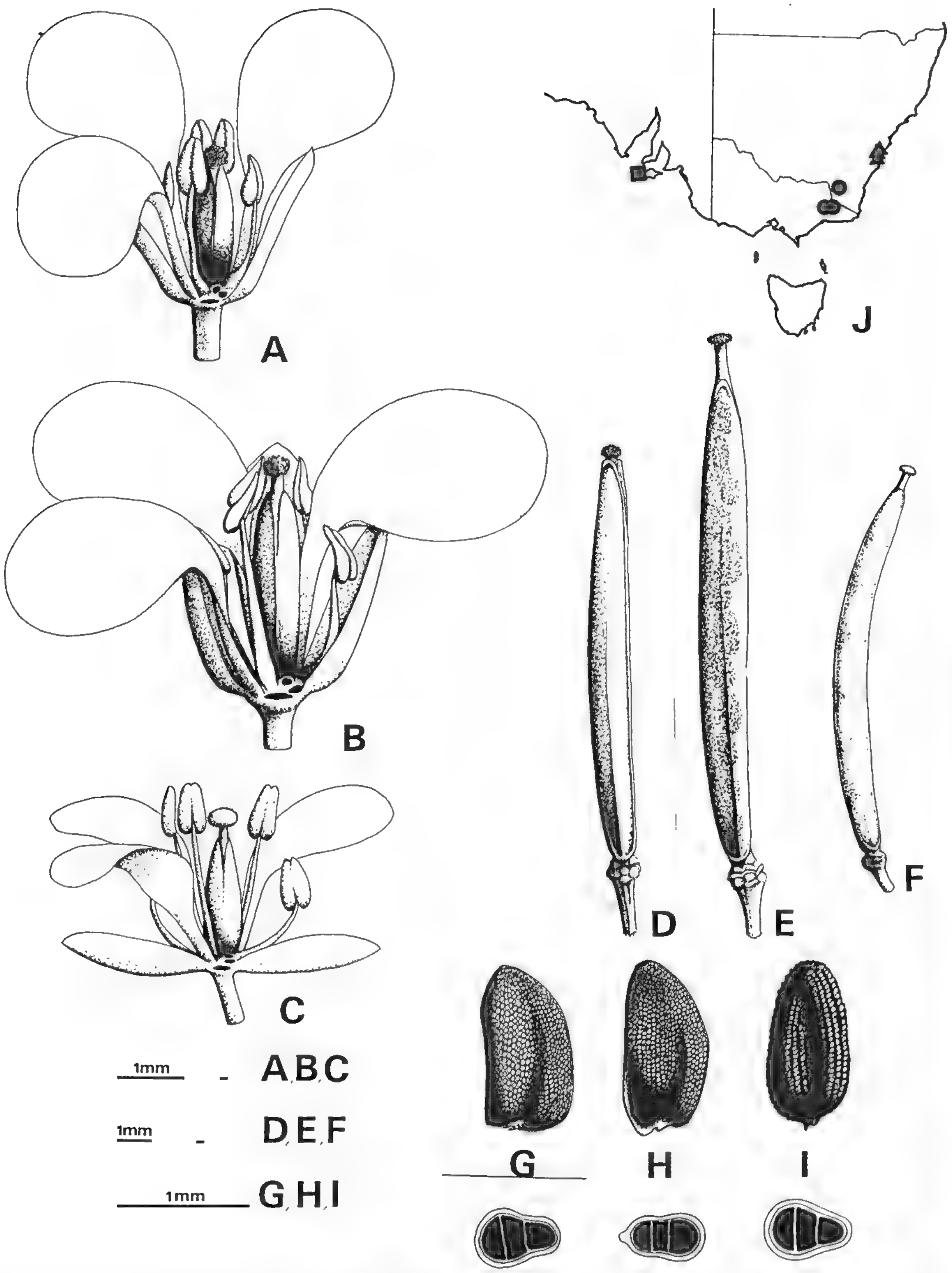

Fig. 1. A, D & G, *Irenepharsus phasmatodes*. A, flower with one sepal, one petal and one stamen removed; D, siliqua; G, seed and diagram of TS of seed. B, E & H, *Irenepharsus magicus*. B, flower with one sepal, one petal and one stamen removed; E, siliqua; H, seed and diagram of TS of seed. C, F & I, *Irenepharsus trypherus*. C, flower with one sepal, one petal and one stamen removed; F, siliqua; I, seed and diagram of TS of seed. J, Distribution: square, *I. phasmatodes*; dots, *I. magicus*; triangles, *I. trypherus*.

1. **Irenepharsus phasmatodes** Hewson, Fl. Aust. 8: 391, 349 (1982).

Holotype: On burnt flat nr. H.S. Rocky River, Flinders Chase, Kangaroo Island (South Australia), *Cleland s.n.*, 29.xi.1923 (AD97449229).

Sisybrium ? sp. : Eichler, Suppl. Black's Fl. S. Austral. 156 (1965).

Annual herb, sparingly branched; stems to 90 cm tall, glabrous, sometimes purple-pigmented. *Leaves* sparsely pubescent with almost sessile branched hairs predominantly 2-fid (some to 4-fid) with branches appressed; basal leaves in a rosette, more or less persistent, pinnatisect to lyrate, to 10 cm long, terminal lobe (when present) wider than rest of leaf, to 2 cm wide, sometimes purple-pigmented; cauline leaves sparse, less than 6 cm long and 3 cm wide, margin entire, the higher ones linear. *Flowering pedicels* c. 0.2 mm wide. *Sepals* 2.0-2.5 mm, green to purple, sometimes sparsely pubescent. *Petals* 3.5-4.5 mm long; blade 2-3.5 x 2-3 mm. Lateral *stamens* 1.5-2 mm long; median ones 2-3 mm long. *Fruiting pedicels* 7-10 mm long and c. 0.2-0.3 mm wide. *Siliqua* 9-22 x 0.9-1.5 mm, straight; valves convex, often purple pigmented; style 0-2-0.7 mm long. *Seeds* 1-1.25 x 0.75 mm, not winged. (Fig. 1 A, D, G & J).

Specimens examined:

SOUTH AUSTRALIA (Flinders Chase National Park, Kangaroo Island): *Hj. Eichler 15375*, sandhill on road to Cape du Couëdic, c. 1.5 km south of Rocky River Homestead, 11.xi.1958 (AD, CANB), *15529*; near West Bay at end of track to the Bay, c. 20 km south of Cape Borda, 15.xi.1958 (AD, CANB); *G. Jackson 716, 717*, on track to mouth of Breakneck, 14.xi.1971 (AD); *P.G. Wilson 966*, c. 3 km from mouth of Breakneck River, 19 km south of Cape Borda, 15.xi.1958 (AD, CANB).

2. **Irenepharsus magicus** Hewson, Fl. Aust. 8: 391, 351 (1982).

Holotype: Growing on mineral soil of embankment in upper Geehi Valley, elev. 3000 ft., (New South Wales) *M. Mueller 1837*, 13.iv.1954 (MEL93359; NSW, isotype).

Annual herb, sparingly to profusely branched; stems to 80 (or more) cm tall, glabrous, green. *Leaves* very sparsely pubescent (to glabrous), hairs (rarely simple) irregularly branched, shortly stipitate, branches appressed to spreading; basal leaves apparently not persistent (not known); cauline leaves denser near base, more remote upwards and reducing in size from 8.5 x 1 cm to less than 2 x 0.2 cm, attenuate to petiolate, narrow ovate to lanceolate, margins serrate (none entire), acute. *Flowering pedicels* c. 0.2 mm wide. *Sepals* 2-3 x 1.25-1.75 mm, green glabrous. *Petals* 4-5.5 mm long; blade 3-3.5 x 2-3.5 mm. *Lateral stamens* 2-2.5 mm long, median ones 2.5-3.0 mm long. *Fruiting pedicels* 7-15 mm long and c. 0.2-0.3 mm wide. *Siliqua* (6) 15-20 (30) x 1.25-1.75 mm, straight; valves convex, green; style (0.75) 1.25-1.50 (1.75) mm long. *Seeds* (1.5) 1.25 x 0.75 (0.9) mm, winged on margin above cotyledon. (Fig. 1 B, E, H & J).

Specimens examined:

VICTORIA (Victorian Alps): *A.C. Beauglehole 35559*, Melick Munjie Rd., N of Melick Munjie Creek, 15.xii.1970 (MEL); *36946*, Windy Ridge Road, off Nunniong Road, 22.ii.1971 (MEL); *37079*, between Dingoes Ridge and Ezards logging Road, 27.ii.1971 (MEL).

3. **Irenepharsus trypherus** Hewson, Fl. Aust. 8: 391, 351 (1982).

Holotype: Rocky cliff face in gorge near falls, Minnamurra Falls Reserve (New South Wales), *E.F. Constable s.n.*, 10.ii.1959 (NSW137707).

Annual herb, slender, branched, spreading to erect, to 1 m tall, glabrous, somewhat mesophytic. *Leaves*: basal leaves unknown; cauline leaves numerous, elliptical to linear-lanceolate, petiolate, dentate to serrate. *Flowering pedicels* c. 0.2 mm wide. *Sepals* 2-2.5 mm long, spreading, somewhat petaloid. *Petals* 3-4 mm long; blade c. 2 x 1.5 mm. Lateral *stamens* 1.5-1.75 mm long, filaments curved; median stamens 1.75-2 mm long,

filaments straight. *Fruiting pedicels* 6-10 mm long, c. 0.2 mm wide, spreading to slightly reflexed. *Siliqua* 5-20 x 0.75-1 mm, curved, ascending; valves somewhat constricted between seeds, green, mid-vein obscure; style 0.75-1.75 mm long. *Seeds* 0.75-1.25 x 0.5-0.75 mm, not winged, sticky (scarcely mucose) when wet. (Fig. 1 C, F, I & J).

Specimens examined

NEW SOUTH WALES (gullies behind the south coast region between Nowra and Wollongong): *Carron s.n.*, Shoalhaven, iii.1861 (NSW); *H.K. Judd s.n.*, Minnamurra Falls, iv.1955 (NSW); *F.A. Rodway 13020*, Upper Kangaroo River, ii.1943 (NSW); *s.n.*, Barrengarry, 29.iii.1948 (PERTH); *anon 30*, ii.1865 (MEL).

Discussion

This genus with its open calyx, one half-prominent mid-vein on the siliqua valves, mucose seeds and incumbent cotyledons belongs in tribe *Sisymbrieae*, subtribe *Arabidopsidinae*. It is close to several other Australian endemic genera in this tribe as circumscribed in a revision by Shaw (1965), viz. *Arabidella* (F. Muell.) O. Schulz, *Drabastrum* (F. Muell.) O. Schulz, *Geococcus* J.L. Drumm. ex Harvey, *Harmsiodoxa* O. Schulz, *Pachymitus* O. Schulz and *Scambopus* O. Schulz (see Table 1). Of these genera *Irenepharsus* is closest to *Pachymitus* and *Drabastrum*. Following the traditional practice for the delimitation of genera in this tribe, one should regard the possession of a reticulate seed testa as setting it apart from *Pachymitus* and the possession of linear fruits as distinguishing it from *Drabastrum*.

Table 1. Affinities of *Irenepharsus* within subtribe *Arabidopsidinae*.

Genus	Hairs	Petals		Nectaries	Fruit		Seeds
	Morphology	Size mm.	Colour	Median Glands Present Absent	Aspect	Shape	Testa
Arabidella	Simple, Papillae or Absent	>2	White or Yellow	+/−	Aerial	Linear	Papillose
Scambopus	Branched	>2	Yellow	+	Aerial	Fusiform	Papillose
Harmsiodoxa	Branched	>2	White to Pink	−	Aerial	Fusiform	Papillose
Geococcus	Branched	1<	White	−	Geotropic	Fusiform	Papillose
Pachymitus	Branched	>2	White to Pink	+	Aerial	Linear	Papillose
Irenepharsus	Branched or Absent	>2	White	+	Aerial	Linear	Reticulate (Fine)
Drabastrum	Branched	>2	White to Pink	−	Aerial	Fusiform	Reticulate (Coarse)

Acknowledgements

Grateful acknowledgement is due to the Australian Biological Resources Study for a substantial grant to support research into the family Brassicaceae; to the Australian Academy of Science for the administration of the grant; to Herbarium Australiense, Division of Plant Industry, CSIRO, for making available their facilities to carry out the research; to Dr A. Kanis and Dr Hj. Eichler for valuable discussion and guidance—(Dr Eichler attempted earlier to place this taxon through correspondence with several leading authorities on the family, but was hampered by lack of mature material); and to the Directors and Curators of the following Herbaria for making specimens available on loan: Adelaide (AD), Melbourne (MEL) and New South Wales (NSW).

Reference

Shaw, E.A. (1965). A critical revision of some endemic Australian genera of Cruciferae. *Trans. Roy. Soc. S. Austral.* 89: 145-253.

J. Adelaide Bot. Gard. 6(1): 5-39 (1982)

A TAXONOMIC REVISION OF THE GENUS *CALLICARPA* L. (VERBENACEAE)* IN AUSTRALIA

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Abstract

A taxonomic revision of Australian *Callicarpa* is presented. Seven species are recognized of which *C. brevistyla* (Northern Territory) and *C. thozetii* (Queensland) are described as new. *C. caudata* and *C. macrophylla* are recorded from Australia for the first time, and *C. pedunculata* is typified. *C. viridis* is regarded as a new synonym of *C. pedunculata*.

The affinities and distribution are considered for the genus and each species. A key to the species is provided and a detailed description of each is supplemented by a habit sketch of a flowering branch and analytical drawings of the flower.

Taxonomic History of the Genus

The genus *Callicarpa* was described by Linnaeus (1753), with one species, *C. americana*, the type of which came from North America. It was placed in "Tetrandria Monogynia" without reference to any family, where it was retained by Murray (1774), Lamarck (1783, 1791), Gaertner (1791), Loureiro (1793), Raeuschel (1797), Roxburgh (1814, 1820), Roemer & Schultes (1818, 1827), Roth (1821), Sprengel (1825) and others. Adanson (1763) placed it in "Jasmina", Rüling (1774) in "Sambuci", Jussieu (1789) in "Vitices", Neckler (1790) in his "Arcytophyta", and Reichenbach (1828) under the tribe "Verbeneae" in the Labiatae. In 1810, Robert Brown referred it to the family Verbenaceae where it has been retained by the majority of botanists.

Endlicher (1836) divided the family Verbenaceae into three tribes: Lippieae, Lantaneae and Aegiphileae, with *Callicarpa* in the tribe Aegiphileae. This tribe was accepted for the genus by Meisner (1840), Endlicher (1841) and Walpers (1845). In 1847, Schauer classified the Verbenaceae into three new tribes: Verbeneae, Viticeae and Avicennieae, with *Callicarpa* in the tribe Viticeae. The genus was retained in the new tribe by Bojer (1837), Miquel (1858), Bentham (1870), Bentham & Hooker (1876), Bailey (1883, 1890, 1901, 1913), Clarke (1885), Durand (1888), King & Gamble (1909), Ewart & Davies (1917), Ridley (1923), Lemée (1943) and others.

In 1895, Briquet reclassified the Verbenaceae and upgraded the tribe Viticeae to a subfamily Viticoideae. The latter consisted of four tribes: Callicarpeae, Tectoneae, Viticeae and Clerodendreae, with *Callicarpa* in the tribe Callicarpeae. This classification was adopted by Dalla Torre & Harms (1904), Lam (1919), Gardner (1931), Junell (1934), Moldenke (1936, 1959, 1971), Melchior (1964) and Lopez-Palacios (1977). The genus *Callicarpa* was divided by Briquet (1895) into two distinct groups: Group 1. *Tubulosae*, characterised by a tubular calyx the rim of which is deeply 4-fid with long and often foliaceous lobes, and Group 2. *Cyathimorphae*, characterised by its campanulate or cyathiform calyx the rim of which is subtruncate and entire or only shortly 4-(or 5-) toothed. Both of these groups were adopted by Dalla Torre & Harms (1904) and Moldenke (1936, 1959, 1971). The majority of botanists, however, have not divided this genus into groups, but have retained it in the Verbenaceae without reference to any tribe or subfamily.

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*The present treatment of the genus *Callicarpa* is the first in a series of taxonomic revisions in the family Verbenaceae in Australia.

Australian History of the Genus

The first Australian records of *Callicarpa* were made by Robert Brown (1810) from northern Queensland, when he described two new species: *C. adenanthera* and *C. pedunculata*. The former was later identified as a synonym of the Asian *C. candicans* (Burm.f.) Hochr. (= *C. cana* L.). Schauer (1847) described one of Robert Brown's collections from Australia as *C. longifolia* Lam. var. *floccosa* Schau. and erroneously placed *C. pedunculata* under *C. lanata* Vahl. In 1859, Hooker listed *C. cana* and *C. longifolia* in his Flora Tasmaniae. Bentham (1870) published a detailed account of the Australian Verbenaceae, and recorded three *Callicarpa* species: *C. cana*, *C. longifolia* and *C. pedunculata* R.Br. Subsequently, the occurrence of these species in Australia was recorded by F. Mueller (1882, 1889) and Bailey (1883, 1901, 1913). Domin (1929) listed these species from Australia, and described a collection of his own from northern Queensland as a new species, *C. viridis* Domin, thus raising the number of *Callicarpa* species in Australia to four. All of these four species were later recorded for Australia by Moldenke (1959, 1971).

In the present treatment, Briquet's (1895) classification of the Verbenaceae is accepted for the genus. *C. viridis* is recognised here as a new synonym of *C. pedunculata*, and *C. caudata* Maxim. & *C. macrophylla* Vahl are recorded for the first time from Australia. In all, seven species are recognised of which one from Queensland and one from the Northern Territory are newly described.

CALLICARPA L.

Callicarpa L., [Act. Soc. Reg. Sci. Ups. (1741) 80], Sp. Pl. edn 1, 1 (1753) 111.

L., Gen. Pl. edn 5 (1754) no. 127; Lam., Encycl. Méth. Bot. 1 (1783) 562; Juss., Gen. Pl. (1789) 107; Gaertn., Fruct. Sem. Pl. 2 (1791) 80; Lour., Fl. Cochinch. edn 2, 1 (1793) 80; Vahl, Symb. Bot. Pl. 3 (1794) 12; R. Br., Prod. Fl. Nov. Holl. (1810) 513; Blume, Bijdr. Fl. Ned. Ind. (1826) 817; Endl., Gen. Pl. 1 (1836) 637, no. 3712; Meisn., Gen. Pl. Vasc. 1, Tab. Diagn. (1840) 292; Gen. Pl. Vasc. 2, Comment. (1840) 200; Steud., Nomen. Bot. 1 (1840) 257; Walp., Rep. Bot. Syst. 4 (1845) 125; Schau. in DC., Prod. 11 (1847) 640; Miq., Fl. Ind. Bat. 2 (1858) 884; Bocq., Rév. Verbénac. (1863) 95, t. 8; Turcz., Bull. Soc. Imp. Nat. Mosc. 2 (1863) 217; Benth., Fl. Aust. 5 (1870) 56; Carruth. in Lindl. & Moore (eds), Treas. Bot. 1 (1870) 195; Stewart & Brandis, For. Fl. N.W. Cent. Ind. (1874) 368; Benth. & Hook. f., Gen. Pl. (1876) 1150; Kurz, For. Fl. Brit. Burma 2 (1877) 273; F. Muell., Syst. Cens. Aust. Pl. 1 (1882) 103; Bail., Synop. Qld Pl. (1883) 377; Clarke in Hook. f., Fl. Br. Ind. 4 (1885) 566; Maxim., Bull. Acad. Sc. St. Petersb. 31 (1887) 74; F. Muell., Sec. Syst. Cens. Aust. Pl. 1 (1889) 173; Briq. in Engl. & Prantl, Pflanzenfam. 4, 3a (1895) 165; Bail., Qld Fl. 4 (1901) 1173; Dalla Torre & Harms, Gen. Siphon. (1904) 432, no. 7177; King & Gamble, J. Asia Soc. Beng. 74 (1908) 802; Mat. Fl. Malay. Pen. (1909) 1012; Ewart & Davies, Fl. N. Terr. (1917) 237; H.J. Lam, Verbenac. Malay. Arch. (1919) 45; H.J. Lam & Backh., Bull. Bot. Gard. Buitenz. III, 3 (1921) 9; Ridley, Fl. Mal. Pen. 2 (1923) 614; Domin, Bibl. Bot. 89 (1929) 554; Gard., Enum. Pl. Aust. Occ. 3 (1931) 112; Junell, Symb. Bot. Ups. 4 (1934) 81; Mold., Fedde Repert. Sp. Nov. Reg. Veg. 39 (1936) 291; Metcalfe & Chalk, Anat. Dicot. 2 (1950) 1034-1037, 1040, 1041; Hutch., Fam. Fl. Pl. edn 2, 1 (1959) 395; Mold., Résumé Verbenac. etc. (1959) 234, 240, 294, 301, 336, 346, 355, 408; Haines, Bot. Bihar & Orissa 2, rep. edn (1961) 743; Burb., Dict. Aust. Pl. Gen. (1963) 50; Prain, Beng. Pl. 2, rep. edn (1963) 617; Back. & Bakh., Fl. Java 2 (1965) 600; T. Cooke, Fl. Pres. Bomb. 2, rep. edn (1967) 502; Mold. Fifth Summary Verbenac. etc. (1971) 390, 402, 519, 531, 532, 604, 625, 643, 740, 757; Clifford & Ludlow, Keys Fam. & Gen. Qld Fl. Pl. (1972) 124; Airy-Shaw, Willis's Dict. Fl. Pl. & Ferns edn 8 (1973) 182; Jafri & Ghafoor in Nasir & Ali (eds), Fl. W. Pak. no. 77 (1974) 19; Lopez-Palacios, Fl. de Venezuela, Verbenac. (1977) 215; Farr, Leus. & Stafleu, Ind. Nom. Gen. Pl. 1 (1979) 263.

Type: *C. americana* L., Sp. Pl. 1 (1753) 111.

Spondylococcus Mitch. ex L., Gen. Pl. edn 5 (1754) 50, pro syn.

Burchardia Heist. ex Duham., Arab. et Arbust. 1 (1755) 111, t. 44.

Johnsonia T. Dale ex Mill., Gard. Dict. edn 7 (1759).

Tomex L. ex Adans., Fam. Pl. 2 (1763) 446.

Illa Adans., Fam. Pl. 2 (1763) 446.

Porphyra Lour., Fl. Cochinch. edn 1, 1 (1790) 69.

Agonon Rafin., Sylv. Tellur. (1838) 161.

Amictonis Rafin., loc. cit. (1838) 161.

Small trees, shrubs or undershrubs. *Stem* and branches almost cylindrical or obtusely tetragonal, more or less floccose-tomentose with stellate or dendriform hairs, sometimes mixed with simple septate hairs. *Leaves* simple, decussate, exstipulate, reticulate-veined, unicostate, petiolate. *Inflorescence* cymose, axillary, solitary in axils of upper leaves, pedunculate. *Flowers* small, bracteate, complete, actinomorphic, bisexual, hypogynous. *Calyx* of 4 sepals, persistent, tubular or shortly campanulate, truncate or minutely 4-toothed. *Corolla* of 4 petals, deciduous, 4-lobed above, tubular below. *Stamens* 4, exserted, isomerous, alternate with the corolla-lobes, epipetalous, inserted near the base of the corolla-tube; filaments filiform, glabrous, of almost uniform length; anthers dorsifixed, oblong or elliptic, 2-lobed, lobes longitudinally dehiscent. *Ovary* bicarpellary, syncarpous, 4-locular, with one ovule in each cell laterally (i.e. axillary) attached at or above the middle; style filiform, usually exserted, (included in *C. brevistyla*), stigma more or less dilated and truncate, obscurely 2-fid. *Fruit* a small globose succulent drupe, endocarp of 4 undivided pyrenes. *Seeds* exalbuminous.

Number of species: World ± 150; Australia 7.

Derivation of Name

The generic name is derived from the Greek *Callos*, beauty, and *carpos*, fruit; alluding to the brightly coloured fruits of the type species. The genus was originally published by Linnaeus in Acta Soc. Reg. Sci. Ups. (1741) 80.

Distribution (Map 1)

The genus *Callicarpa* is widely distributed in warm temperate and tropical America, the West Indies, eastern and southern Asia including India, Burma, Thailand, Indochina, Malesia, tropical Australia, Polynesia and Oceania. So far, it has not been recorded from Europe, Africa, Central and Southern Australia, New Zealand, and Fiji, except in cultivation.

Of the seven Australian species two are endemic in Australia and the other five are widely dispersed in Malesia. The distribution of at least two of these species extends over the Indian Archipelago and up to northern India and southern China.

Comments

Briquet (1895) divided the genus into two groups, namely *Tubulosae* and *Cyathimorphae*, the former characterised by a tubular calyx with distinctly long lobes, and the latter with a campanulate or cyathiform calyx with entire or subtruncate rim bearing only 4 short teeth. All Australian species come under the group *Cyathimorphae*.

The members of the genus appear to inhabit almost every type of habitat. According to Moldenke (1936), they occur "from sea level on isolated islands to the high alpine regions of the Andes and Himalayas, from swamps and marshy ground to rocky cliffs, plateaus, sand-dunes, and dense forests". In view of their handsome fruits, many species are widely cultivated in both Old and New Worlds. Probably most, if not all, of the species can be grown from cuttings. The fruits in most species are said to be devoured extensively by birds and seed dispersal thus effected.

In different countries, the genus is known locally by different names. According to Moldenke (1936), the English names for the genus are "French-mulberry", "Spanish-mulberry", and "beauty-berry"; German names are "Wirbelbeere", "Wirtelbeere", and "Schönfrucht"; while in French a member of this genus is usually spoken of as "callicarpa". The Japanese designation is "murasaki"—a word originally denoting the colour purple, which being the most esteemed colour in Nippon, the name gradually came to be applied to anything or any person of exceptional beauty or especially esteemed. Merrill (1923) gave several local names for each *Callicarpa* species in the Philippines.

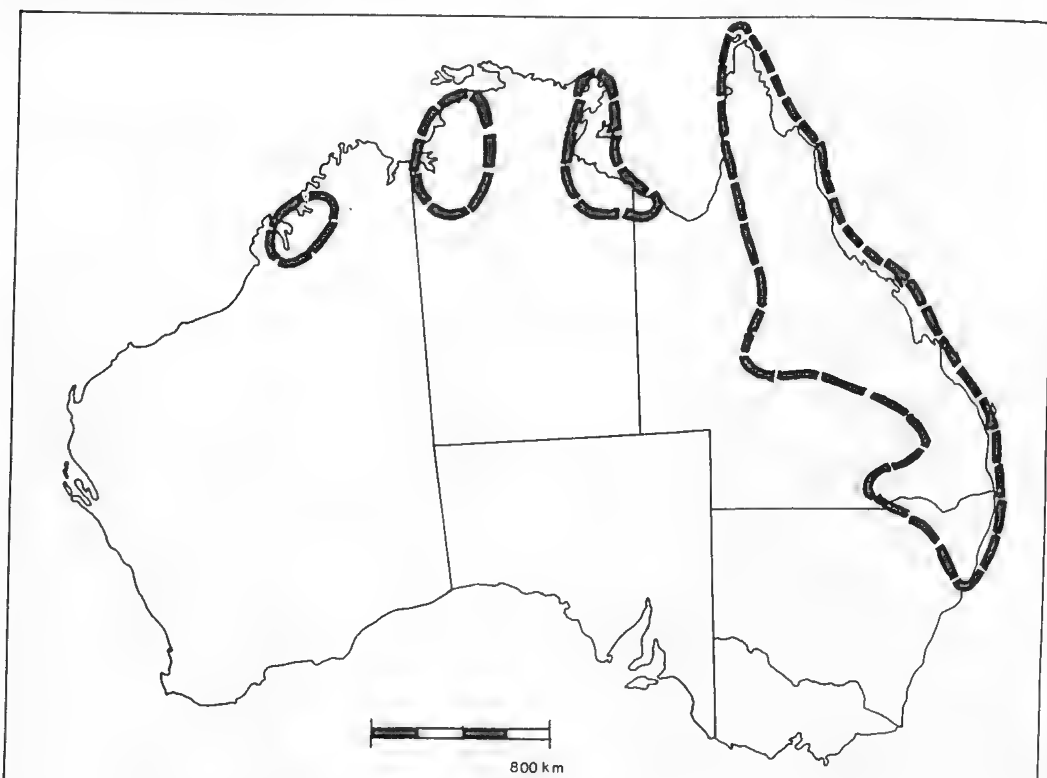
Affinities

Callicarpa is closely related to *Geunsia* Blume in its inflorescence being a panicle with few to many cymes; corolla regular; stamens isomerous, equal, inserted at or near the base of the corolla-tube; stigma depressed-capitate or peltate; fruiting calyx non-accrescent; fruit a drupe. Nevertheless, *Callicarpa* can easily be distinguished by its leaves being isophyllous, flowers 4-merous, stamens usually 4, ovary 2-carpellary and drupe with 4 pyrenes. The leaves in *Geunsia* are anisophyllous, flowers 5-merous, stamens usually 5, ovary usually 5-carpellary and drupe with 5-2 pyrenes. *Callicarpa* is also close to *Tectona* L. f. in having a cymose inflorescence, actinomorphic flowers, regular corolla, isomerous stamens and drupaceous fruit. *Tectona*, however, may readily be identified by its tall size (i.e. trees), drupe composed of one 4-celled pyrene and fruiting-calyx often conspicuously accrescent.

Moldenke (1936) regarded *Callicarpa* as being most closely related to *Aegiphila* Jacq. which is confined entirely to tropical and subtropical America. The latter differs in its stigma being deeply divided into 2 awl-shaped branches, flowers diclinous, fruiting-calyx enlarged and indurate, stamens inserted at or above the middle of the corolla-tube and inflorescence frequently terminal and thyrsoid.

Among the Australian genera of the Verbenaceae, *Callicarpa* seems nearest to *Premna* L. in having simple leaves; cymose inflorescence, usually 4-lobed corolla with a short tube, 4 stamens, and drupaceous fruit. The latter, however, can easily be distinguished by its inflorescence being a terminal panicle, calyx and corolla more or less 2-lipped, stamens didynamous or subequal and drupe with one 4-celled pyrene.

A key to Australian general of the Verbenaceae will be published at the conclusion of this series of generic revisions.



Map 1. Distribution of the genus *Callicarpa* L. in Australia.

Key to the species

1a. Lamina cuneate at the base 2

b. Lamina rounded, obtuse, truncate or subcordate at the base 5

2a. Primary peduncles longer than the petioles; corolla-lobes hairy outside .... 1. *C. thozetti*

b. Primary peduncles shorter than the petioles; corolla-lobes glabrous or in *C. longifolia* pubescent outside 3

3a. Corolla white, pubescent outside; leaves rusty-brown or ferruginous-tomentose on abaxial surface; ovary hairy at the top; fruit white .... 2. *C. longifolia*

b. Corolla purple, violet or mauve, glabrous; leaves greyish-white or yellowish-white-tomentose on abaxial surface; ovary glabrous; fruit purple, pink or violet 4

4a. Style included, ± 1 mm long; leaves broadly elliptic-ovate or orbicular, entire, undulate or slightly denticulate .... 3. *C. brevistyla*

b. Style exserted, 5-6 mm long; leaves usually elliptic-oblong, lanceolate or ovate-lanceolate, distinctly serrate-dentate .... 4. *C. candicans*

5a. Leaves greyish-white-tomentose on abaxial surface; peduncles equal to or somewhat longer than the petioles; fruit white .... 5. *C. macrophylla*

b. Leaves yellowish-brown- or ferruginous-tomentose on abaxial surface; peduncles always longer than the petioles; fruit purple, pink or violet 6

6a. Indumentum on branches and peduncles mostly of simple septate hairs, 1-2 mm long; leaves narrowly lanceolate, with long tapering apex .... 6. *C. caudata*

b. Indumentum on branches and peduncles of stellate-dendriform hairs, 0.5-0.8 mm long; leaves ovate-lanceolate or broadly oblong-lanceolate, with cuneate or short tapering apex .... 7. *C. pedunculata*

1. **Callicarpa thozetii** Munir, sp. nov.

Frutex erectus. *Caulis* et rami ferrugineo-tomentosi. *Folia* elliptica; lamina basin versus cuneata, dentata, (6-) 8-12 cm longa, 3-5.8 cm lata, superne pubescentia, infra dense ferrugineo-tomentosa. *Pedunculi* primarii petiolis longiores, aliquantum crassi, 1-2 cm longi. *Flores* breviter pedicellati. *Calyx* tubularis, minute 4-dentatus. *Corolla* caerulea vel lilacina, 2-2.5 mm longa; lobis extra (i.e. dorsaliter) glandulosis et hirsutis. *Stamina* 4, exserta; filamentis glabris. *Ovarium* glabrum et glandulosum. Stylus exertus, glaber. *Fructus* globosus, drupa succulenta, glaber, glandulosus, ubi maturus et vivus manifeste purpureus, 2-2.5 mm diametro.

Type: *A. Thozet s.n.*, Rockhampton, Queensland, Australia, undated (MEL 97646, holotype).

Description (Fig. 1)

An erect branched shrub. *Stem* and branches densely clothed with ferruginous tomentum of chiefly dendriform hairs. *Leaves*: lamina elliptical, cuneate towards the base, dentate, acute, (6-) 8-12 cm long, 3-5.8 cm broad, membranous, sparsely glandular and densely pubescent above with simple and dendriform hairs, glandular and densely greyish-brown- or pale ferruginous-tomentose beneath with stellate-dendriform hairs; petioles shorter than the primary peduncles, densely dendriform-tomentose, amplexicaul at the base when young, 5-8 mm long. *Inflorescence* rather lax, primary peduncles longer than the petioles, rather thick, 1-2 cm long, densely brown-tomentose. *Flowers* shortly pedicellate; pedicel glandular, densely tomentose, 0.5-1.5 mm long. *Calyx* cup-shaped, minutely 4-toothed at the top, glandular and densely tomentose outside with stellate-dendriform hairs, glabrous inside, 1-1.5 mm long, about the same in diameter at the top. *Corolla* blue or lilac, glandular and hairy on the back (i.e. outside) of each lobe, glabrous elsewhere, 2-2.5 mm long; lobes obtuse, almost orbicular, ± 1 mm long, nearly as broad; tube cylindrical, 1-1.5 mm long. *Stamens* inserted near the base of corolla-tube; filaments (2-) 2.5-3 mm long; anthers almost orbicular in outline, densely glandular along the connective on both the faces, ± 0.5 mm long, nearly as broad. *Ovary* globular,

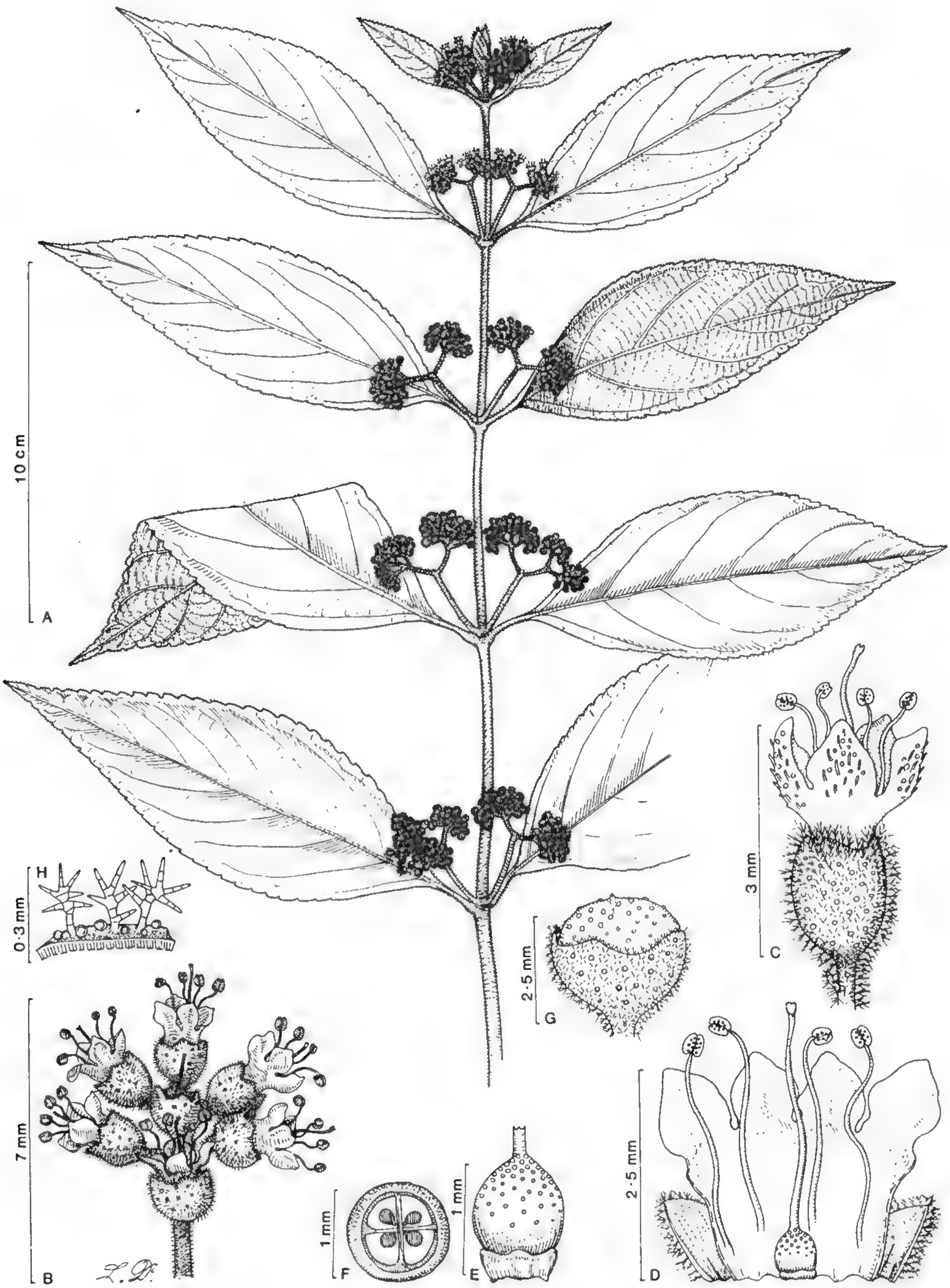


Fig. 1. *Callicarpa thozetii* Munir (A-H, *A. Thozet s.n.*: MEL 97646). A, flowering branch; B, cyme; C, flower; D, flower vertically cut open to show androecium and gynoecium; E, ovary; F, transverse section of ovary; G, fruit with persistent calyx; H, portion of calyx showing hairs and glands.

glabrous, glandular, 0.5-1 mm in diameter; style exserted, filiform, glabrous, 3-4 mm long, stigma capitate, slightly notched at the top. *Fruit* a globose succulent drupe, glabrous, glandular, deep purple when ripe, turning blackish when dry, 2-2.5 mm in diameter.

Specimens examined

AUSTRALIA: QUEENSLAND: *Blake 12731*, Mt Berserker, 6.iii.1937 (BRI); *Dallachy 54*, Rockhampton, 26.xii.1862 (MEL 97640 p.p., alter parte *C. pedunculata* R. Br.); *Dallachy s.n.*, loc. incert., undated (MEL 97641); *Dietrich 726*, Rockhampton, Feb. 1866 (MEL 97746). *Thozet 3*, Rockhampton, undated (MEL 97643); *Thozet s.n.*, Rockhampton, undated (MEL 97646, holotype).

Distribution (Map 2)

C. thozetii seems to be endemic in the eastern tropics of Australia where it has been recorded from near Rockhampton in Queensland.

Comments

All collections of *C. thozetii* were formerly identified as *C. pedunculata*. The long primary peduncles and ferruginous indumentum on stem and leaves are prominent and common characters between the two species.

In some cymes, one or two flowers are found to be 5-merous which is scarcely noticeable during routine examination of the specimen. These flowers are regarded here as abnormal.

Thozet's collection no. 3 (MEL 97643) from the type locality is not an isotype.

Affinities

C. thozetii is closely related to *C. pedunculata* in its primary peduncles being longer than the petioles; leaf lamina ferruginous-tomentose beneath; indumentum on stem and inflorescence of stellate-dendriform hairs; corolla blue or violet; ovary glabrous, glandular; fruit deep purple when ripe. Nevertheless, *C. thozetii* may easily be distinguished by its lamina being cuneate at the base, corolla-lobes hairy outside and stamens and style much less exserted.

C. thozetii is also allied to *C. candicans* in having the leaf lamina cuneate at the base; indumentum on branches and peduncles of stellate hairs; corolla violet-mauve; ovary glabrous, glandular and fruit purple when ripe. However, *C. thozetii* can readily be identified by its primary peduncles being longer than the petioles; corolla-lobes hairy outside and lamina ferruginous-tomentose underneath.

2. **Callicarpa longifolia** Lam., Encycl. Meth. Bot. (1783) 563, t. 69, f. 2.

Vahl, Symb. Bot. Pl. 3 (1794) 13; Raeusch., Nomencl. Bot. edn 3 (1797) 37; Willd., Linn. Sp. Pl. 1 (1798) 620; Roxb., Hort. Beng. (1814) 83; Roem. & Schult., Syst. Veg. 3 (1818) 96; Hook., Fl. Exot. 1 (1823) 133; Lindl. in Edwards (ed.), Bot. Reg. 10 (1824) t. 864; Blume, Bijdr. Fl. Ned. Ind. (1826) 817; Spreng., Syst. Veg. 1 (1825) 420; Roem. & Schult., Linn. Mant. Syst. Veg. 3 (1827) 53; Spreng., Syst. Veg. 4 (1827) 41; Roxb., Fl. Ind. 1 (1832) 394; Hassk., Cat. Pl. Hort. Bot. Bog. (1844) 136; Walp., Rep. Bot. Syst. 4 (1845) 128; Schau. in DC., Prod. 11 (1847) 645; Miq., Fl. Ind. Bat. 2 (1858) 887 & Suppl. 1 (1861) 243 & 569; Benth., Fl. Hongk. (1861) 270; Fl. Aust. 5 (1870) 57; Brand., For. Fl. NW. & Centr. Ind. (1874) 369; Kurz. For. Fl. Br. Burma 2 (1877) 275; F.-Vill., Novis. App. (1880) 158; F. Muell., Syst. Cens. Aust. Pl. 1 (1882) 103; Bail., Synop. Qld Fl. (1883) 377; Clarke in Hook. f., Fl. Br. Ind. 4 (1885) 570; Maxim., Bull. Acad. Sc. St. Pet. 31 (1887) 77; Bail., Rep. Gov. Sc. Exped. Bell.-Ker (1889) 52; K. Schum. & Hollr., Fl. Kais. Wilh. Land (1889) 119; F. Muell., Sec. Syst. Cens. Aust. Pl. 1 (1889) 173; Bail., Cat. Pl. Qld (1890) 35; Forb. & Hemsl., J. Linn. Soc. (Bot.) 26 (1890) 253; Kuntze, Rev. Gen. Pl. 1 (1891) 503; Bail., Bot. Bull. 8 (1893) 81; Qld Woods (1899) 104; Hemsl., Kew Bull. & Misc. (1899) 108; Koord. & Valeton, Bijdr. Booms Java, no. 7 (1900) 176; Bail., Qld Fl. 4 (1901) 1174; K. Schum. & Lauterb., Fl. D. Südsee (1901) 522; Williams, Bull. Herb. Boiss. 2nd Ser. 5 (1905) 430; King & Gamble, J. As. Soc. Beng. LXXIV, 4 (1909) 807; Fl. Mal. Penin. no. 21 (1909) 1017; Koord., Exkurs.-Fl.

Java 3 (1912) 134; Bail., Comp. Cat. Qld Pl. (1913) 386; H.J. Lam, Verbenac. Malay. Arch. (1919) 86; B. Leeuwen, Faber & Smith, Bull. Jard. Bot. 3rd Ser. 4 (1922) 284; Merr., Enum. Philip. Fl. Pl. 3 (1923) 385; Ridley, Fl. Mal. Penin. 2 (1923) 616; White, Proc. Roy. Soc. Qld 34 (1923) 50; Heyne, Nutt. Pl. Ned. Ind. 2nd edn 2 (1927) 1311; Domin, Bibl. Bot. 89 (1929) 555; Hochr. in Candollea 5 (1934) 190; Junell, Symb. Bot. Ups. 4 (1934) 81, 83; Mold., Fedde Repert. Sp. Nov. Reg. Veg. 40 (1936) 96; Résumé Verbenac. etc. (1959) 200, 208, 211, 234, 241-248, 298, 319; Fifth Summary Verbenac. etc. (1971) 344, 349, 390, 404-408, 410-413, 418, 526, 570; Phytologia 21 (1971) 376; Everist, Poison Pl. Aust. (1974) 518; Wrig. & Fagg, Aust. Native Pl. (1979) 184.

Type: *Sonnerat s.n.*, Malacca, Malaysia.—(P. LA, microfiche!). Collector's name and the locality for the type are taken from the protologue because they are lacking on the microfiche of Lamark's herbarium in Paris.

C. lanceolaria Roxb., Fl. Ind. 1 (1820) 409; Link, Enum. Pl. 2 (1822) 124; Spreng., Syst. Veg. 1 (1825) 420; Roem. & Schult., Linn. Mant. Syst. Veg. 3 (1827) 54; Walp., Rep. Bot. Syst. 4 (1845) 129.

Type: *H. Koamoora 763*, Silhet, Eastern India, 1815 (C, microfiche!).

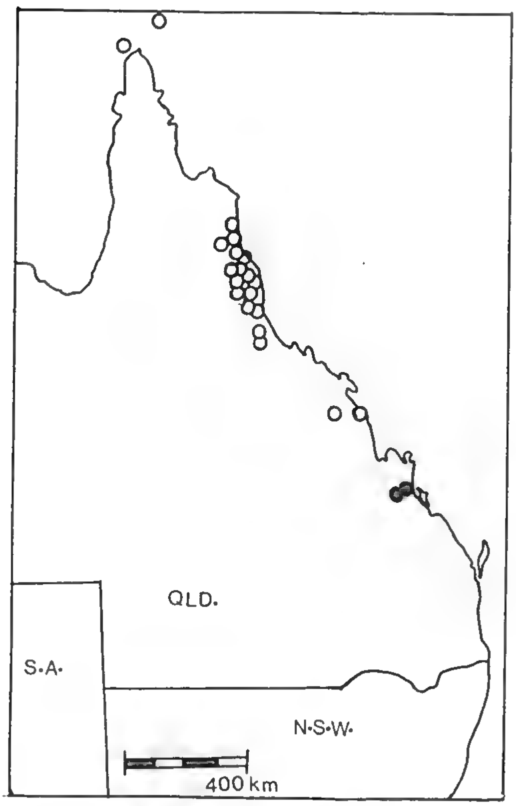
C. albida Blume, Bijdr. Fl. Ned. Ind. (1826) 818.

Type: "Crescit in montosis. Floret omni tempor" (n.v.). In the protologue there is no mention of any locality or the name of a collector, but the type is most likely in Herb. L or BO, n.v.

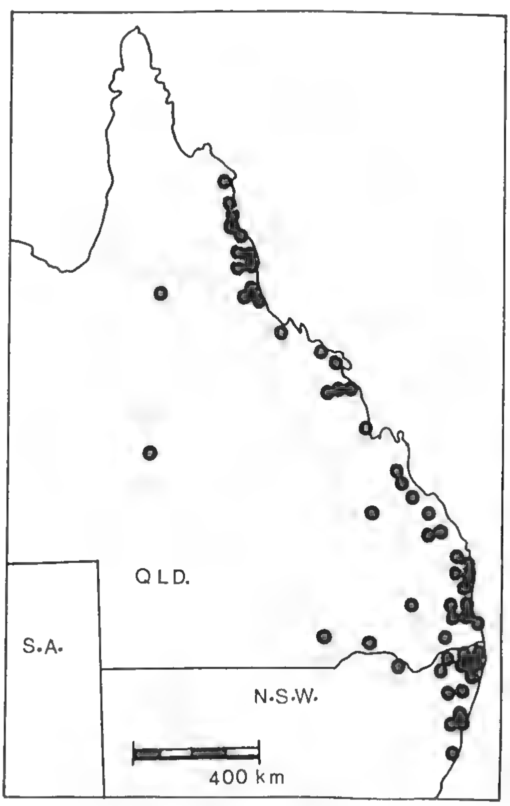
C. roxburghiana Roem. & Schult., Linn. Mant. Syst. Veg. 3 (1827) 54; Walp., Rep. Bot. Syst. 4 (1845) 128.

Type: Prince of Wales Island (n.v.). This taxon is based on *C. longifolia* Roxb. (1820).

C. cana auct. non Linn.: Wall., Cat. (1828) no. 1834 p.p.



Map 2. *C. thozetii* ●
C. longifolia ○



Map 3. *C. pedunculata* ●

C. oblongifolia Hassk., Cat. Hort. Bot. Bogor. (1844) 136, nom. nud.

C. blumei Zoll. & Mor., Syst. Verz. Zoll. (1846) 53, based on the description and the specimen of Blume's *C. longifolia* Lam. (1825).

Type: "Crescit in fruticetis montosis. Floret toto anno". There is no mention of collector or the locality (n.v.).

C. longifolia Lam. var. *floccosa* Schau. in DC., Prod. 11 (1847) 645, excl. syn. *C. adenanthera* R. Br.; Miq., Fl. Ind. Bat. 2 (1858) 888; Kuntze, Rev. Gen. Pl. 3 (1891) 503; Heyne, Nutt. Pl. Ned. Ind. 2nd edn, 2 (1927) 1311; Mold., Phytologia 2 (1971) 376.

Type: *Roxburgh s.n.*, Eastern India, Prince of Wales Island, undated (DC-G, microfiche!). *Gaudichaud s.n.*, Singapore & Manila, 1839 (DC-G, microfiche!). *Thunberg s.n.*, Java, undated (DC-G, microfiche!). *Blume & Jungh s.n.*, loc. cit. (n.v.). *R. Brown s.n.*, N. Hollandia (n.v.).

C. longifolia Lam. var. *subglabrata* Schau. in DC., Prod. 11 (1847) 645, excl. syn. *C. japonica* Thunb.; Heyne, Nutt. Pl. Ned. Ind. 2nd edn, 2 (1927) 1311; Beer & H.J. Lam, Blumea 2, no. 3 (1936) 221; Hatus, J. Jap. Bot. 24 (1949) 81; Burkill, Dict. Econ. Prod. Mal. Penin. 1 (1966) 407, 408.

Type: *Wallich cat. no. 1829*, in India orient. e. gr. Prov. Silhet, undated (DC-G, microfiche! 3 spec.). *Zollinger 156, 223, 349*, Java, 1843 (DC-G, microfiche!). *Blume s.n., Junghuhn s.n.*, Java, (n.v.). *Cuming 1330*, Philippine (n.v.).

C. lanata Vahl var. *uberior* Miq., Fl. Ind. Bat. 2 (1858) 887.

Type: From Sumatra, undated (n.v.). The collector's name is not given with the protologue.

C. longifolia Lam. var. *lanceolaria* (Roxb.) Clarke in Hook. f., Fl. Br. Ind. 4 (1885) 570, based on *C. lanceolaria* Roxb. (1820); Prain, Beng. Pl. 2, rep. edn (1963) 618.

Type: As for *C. lanceolaria* Roxb.

C. attenuifolia Elm., Leafl. Philip. Bot. 8 (1915) 2870.

Type: *A.D.E. Elmer 13536*, Cabadbaran (Mt Urdaneta), Province of Agusan, Mindanao, Aug. 1912 (n.v.), probably in Herb. PNH.

C. longifolia Lam. var. *areolata* H.J. Lam, Verbenac. Malay. Arch. (1919) 90.

Type: *Leeuwen & Reijnvaan 1349*, Kalao Toa-Island, 5.v.1903 (n.v., probably in Herb. L or BO).

Description (Fig. 2)

A shrub or small tree 2-4 m tall. *Stem* and branches densely stellate-hairy when young, almost glabrescent when mature. *Leaves*: lamina lanceolate, oblong, oblong-lanceolate or narrowly elliptic-oblong, acuminate with a long point, serrate, cuneate at the base, 7-18 cm long, 2.5-6.5 cm broad, membranous, green, almost glabrous or sprinkled with very short hairs above, more copiously tomentose and glandular underneath, often slightly brownish-rusty beneath; petiole stellate-hairy, 0.7-2(-2.5) cm long. *Inflorescence* densely stellate-hairy when young, almost glabrescent when mature; primary peduncles shorter than the petioles, densely stellate-hairy, rusty, 0.3-1.3 (-1.7) cm long. *Flowers* subsessile; pedicels ± 0.5 mm long. *Calyx* cup-shaped, minutely 4-toothed, densely glandular and floccose outside, glabrous within, 1-1.5 mm long, ± 1 mm in diameter in flower and up to 2 mm diameter in fruit. *Corolla* white, pubescent outside with a few glands on the back of each lobe, glabrous within, 2-2.5 mm long; lobes broadly ovate or almost orbicular, obtuse, 0.5-1 mm long, nearly as broad at the base; tube cylindrical but narrowed towards the base, ± 1.5 mm long, almost 1 mm in diameter at the top. *Stamens* inserted near the base of the corolla-tube; filaments filiform, glabrous, 2.5-3.5 (-4) mm long; anthers oblong, glandular on both sides, 0.5-0.8 mm long, ± 0.5 mm broad. *Ovary* globose, densely glandular with a few hairs at the top, ± 0.5 mm in diameter; style exserted, glabrous, 4-6 mm long, stigma capitate, slightly bifid. *Fruit* globular, almost succulent when fresh, 1.5-3 mm in diameter, glandular with a few small hairs on the top, white when mature.

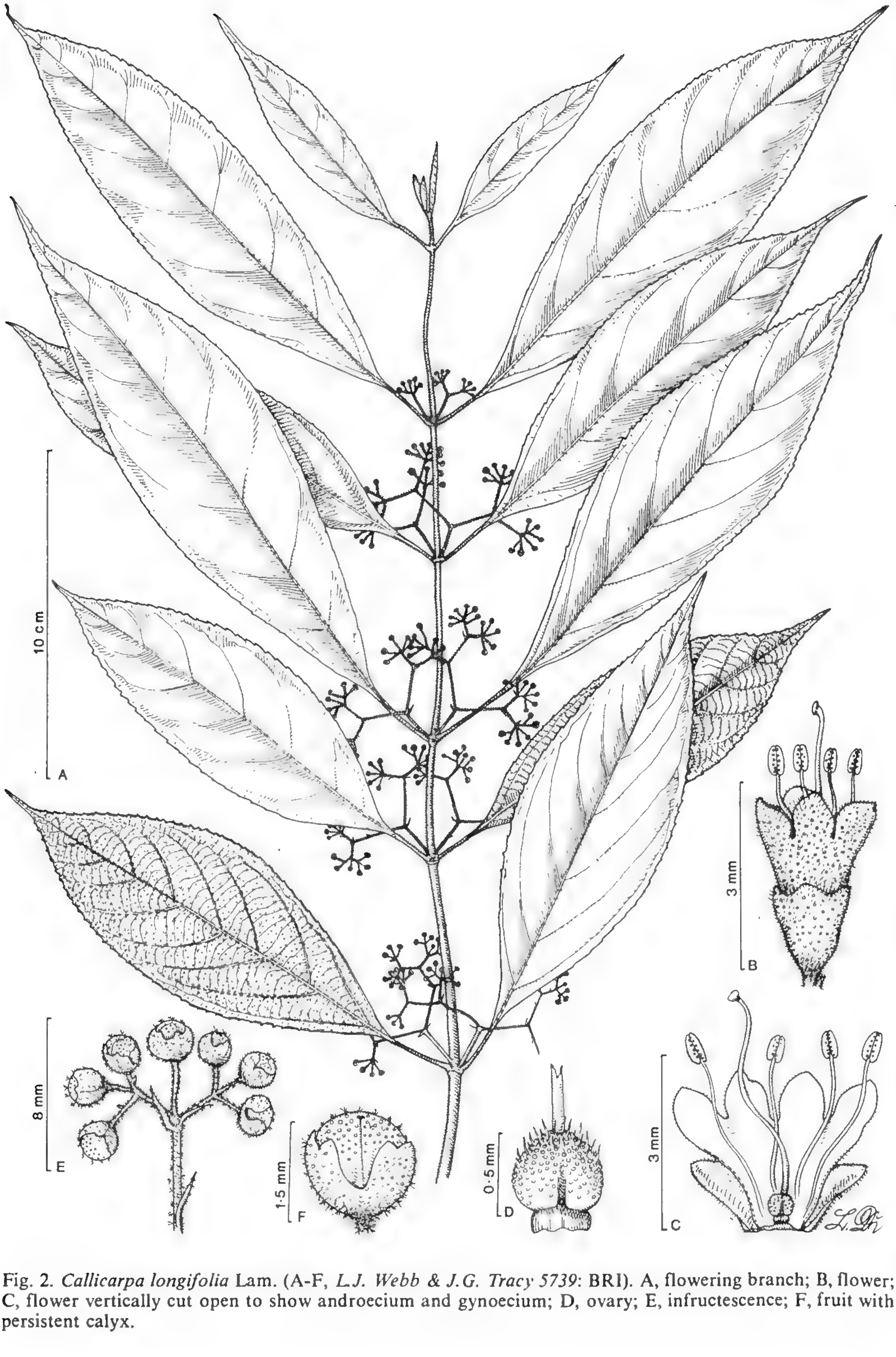


Fig. 2. *Callicarpa longifolia* Lam. (A-F, *L.J. Webb & J.G. Tracy 5739*: BRI). A, flowering branch; B, flower; C, flower vertically cut open to show androecium and gynoecium; D, ovary; E, infructescence; F, fruit with persistent calyx.

Representative specimens (collections seen: Australian 47, non-Australian 116)

AUSTRALIA: QUEENSLAND: *Andrews & Simon 181*, near Cardwell, 10.v.1975 (BRI); *Dallachy s.n.*, Murray River, 4.xii.1860 (MEL 97627); *Dallachy s.n.*, Rockingham Bay, 2.xii.1864 (MEL 97628); *Dietrich 2458 & 2498*, Port Mackay, 16.v.1869 (MEL, PR); *Lawrie s.n.*, Murray Island, 30.i.1971 (BRI 118976); *Sayer 199*, Harvey's Creek, Russell River, 1887 (MEL); *Stocker 683*, S.F.R. 194, Compartment 54, 17° 20′ S, 145° 25′ E, 15.iv.1971 (BRI, CANB, LAE, QRS); *Webb & Tracy 7883*, Thursday Island, 1962 (BRI); *White 1405*, Daintree River, 29.xi.1929 (BRI); *White 12977*, Eungella Range, 3.ix.1938 (BRI, CANB).

NEW GUINEA: *Brass 1013*, Vailala River, 19.ii.1926 (BRI); *Coode & Katik NGF 32782*, Aiome to Ramu River, 11.iii.1968 (BRI, CANB, L, LAE); *Craven & Schodde 1414*, near Kwaimengu, 23.iv.1966 (BRI, CANB, A, K, L, LAE, PNH, US); *Forbes 783*, S.E. New Guinea, 1885-6 (MEL); *Forman & Vinas LAE 60285*, near Boridi sub-dist., Port Moresby, 09° 05′ S, 147° 38′ E, 2.x.1973 (BRI, L, LAE); *Henty NGF 11980*, Busu River near Lae, 5.iv.1960 (BRI, CANB, LAE, MEL); *Millar NGF 12223*, Busu River near Lae, 21.vi.1960 (BRI, CANB, LAE); *Schodde & Craven 4274*, junction of Lohiki and Vailala Rivers, 24.i.1966 (BRI, CANB, A, BO, K, L, LAE, SING, US).

NEW BRITAIN: *K.J. White NGF10045*, near Urin, Eliak, South New Britain, 6.v.1958 (BRI, LAE).

MOLUCCAS: *Buwalda 4316*, Tanimbar Island, P. Jamdena, 19.iii.1938 (BRI, BO).

BORNEO: *Chew, Corner & Stainton s.n.*, Mt Kinabalu, 06° 00′ N, 116° 35′ E, 1961 (CANB); *Elmer 20102*, Sandakan, Myburgh Prov., Oct.-Dec. 1921 (BRI); *Kostermans 6503*, Loa Djanan, W. of Samarinda, 17.iv.1952 (BRI, BO).

JAVA: *Andrews s.n.*, Christmas Island, 1908 (MEL 97782); *Kostermans 18557*, W. Sumbawa, Mt Batulanteh, 29.iv.1961 (CANB, BO).

SUMATRA: *Beccari 491*, Ajer Mantjoer, W. Sumatra, Aug. 1878 (MEL).

MALAYA: *Burkill 245*, Pangkor Island, 8.vii.1955 (BRI, SING).; *Millard KL1863*, Ulu Langat, Selangor, 25.xi.1959 (QRS, KEP).

THAILAND: *Kasin 395*, near Neeckay, Wangka, 16.v.1946 (BRI, L).

BURMA: *Wood s.n.*, Pangsalap, 1.i.1903 (MEL, CAL).

INDIA: *U. Singh 81*, Dehra Dun, U.P., 1928 (BRI, DD).

Distribution (Map 2)

In Australia, *C. longifolia* is found only in Queensland where it occurs chiefly in the north-eastern coastal region between Cooktown and Mackay. Within this area, the main concentration of this species is on the Atherton Tableland. There are also three records from the Torres Strait Islands of which one came from Murray Island close to the New Guinea shore and the others from Thursday Island and Prince of Wales Island near the tip of Cape York Peninsula. The record by Roxburgh of this species from the Prince of Wales Island (Schauer, 1847) has not been confirmed by modern collections. It is doubtful whether Roxburgh did any collecting on the island with that name in northern Queensland.

From outside Australia, specimens have been examined from New Guinea, New Britain, the Moluccas, Borneo, Java, Sumatra, Malaya, Thailand, Burma and India. Lam (1919) gave its distribution as being from Eastern India, Bangladesh, most parts of Malesia but not Australia. In addition to the above localities, Moldenke (1971) recorded it from Peru, Bhutan, Southern China, Hainan, Andaman Islands, Mergui Archipelago and Indochina. From Australia, he recorded it from Queensland and the Northern Territory. It is possible that this species may be found in the tropics of the Northern Territory but so far no Australian herbarium seems to have any collection from this area.

Everist (1974) recorded it as growing "mainly in wet tropical lowland areas of North Queensland, often as regrowth in cleared swampy rainforest country".

Comments

Besides the typical variety, Schauer (1847) described two varieties under this species, namely var. *subglabrata* and var. *floccosa*. He based the former on specimens from

eastern India, Java, the Philippines and Japan. The last named locality seems doubtful because this species is not known to occur in Japan. Similarly, Schauer included *C. japonica* Thunb. (1760) in the synonymy of var. *subglabrata*, but the former had already been recognized as a distinct species. He based the other variety, *floccosa*, on specimens from eastern India, Singapore, Java, the Philippines, the Prince of Wales Island and the tropics of Nova Hollandia in which areas this species seems to occur commonly. Under this variety, *C. adenanthera* R. Br. (1810) was cited as a synonym but this has been recognized by Bentham (1870) as conspecific with *C. candicans* (Burm. f.) Hochr. (= *C. cana* L.).

Both the varieties have been distinguished chiefly on the nature, colour and density of indumentum on branches, inflorescence and calyces. Since *C. japonica* Thunb. and *C. adenanthera* R. Br. have been included under var. *subglabrata* and var. *floccosa* respectively, it seems that the characters used in distinguishing these varieties have probably been taken partly from these two species. In any case, the colour and density of indumentum in *C. longifolia* varies at different stages of plant growth. In young plants, the indumentum is fairly dense and deep rusty-brown, but in fully developed or old plants, the leaves, branches and peduncles become somewhat glabrescent and the colour of indumentum also fades to a certain degree. In view of this, the characters used by Schauer (1847) in distinguishing var. *subglabrata* and var. *floccosa* from var. *longifolia* are considered unstable. Therefore, the former two varieties are regarded here as belonging to the typical variety.

According to Moldenke (1936) this species "is extremely variable and polymorphic, and has been greatly misinterpreted in the past. Specimens of all sort of widely separated species have from time to time been included under the name *C. longifolia*, causing a great confusion in the literature".

Bentham (1870) recorded this species as: "*C. longifolia* Lam. ex Schau in DC . . ." showing that this name was first validated by Schauer (1847). Actually, this species was named and first validly published by Lamarck (1783) who provided it with a short description in Latin and a long one in French. Therefore, the authorship of this species should be referred to Lamarck, not Schauer.

According to Dr T.G. White's note with his collection no. BRI 2060727 "the bark of this species is used by the Javanese on the Johnstone River as a substitute for the Betel-leaf, when chewing the Areca nut with lime". Burkill (1966) says that "it is one of the chief plants used for poulticing by Malays, and is also administered internally. For colic a decoction of the leaves is drunk. A similar decoction is given after childbirth, and for fever. For syphilis an infusion of the root is used . . . . . . and Rumpf says a decoction of the root is useful for diarrhoea. A decoction of the root of some species of *Callicarpa*, such as this, is prescribed . . . . . . for distention of the stomach, the treatment comprising bathing the body by a decoction of the leaves. The leaves are used by the Malays for poulticing in fever, and for rubbing over the body and are applied to swellings. A lotion containing the juice of the root is used for nasal caries . . . . . ."

Of all the Australian *Callicarpa* species, *C. longifolia* is the only one with a white corolla. This species is called "long-leaved *Callicarpa*" by some. It is said to bloom chiefly from June to August, but in greenhouse cultivation it may bloom at other times as well.

According to Moldenke (1971), this species is cultivated in Australia, Java, Malaya, India, Belgium, France, Peru and the United States of America.

Affinities

C. longifolia is closely related to *C. brevistyla* and *C. candicans* in its leaf lamina being cuneate at the base; primary peduncles shorter than the petioles and indumentum

on branches and peduncles of stellate-dendriform hairs. However, *C. longifolia* may easily be distinguished by its corolla being white, pubescent outside; leaves rusty-brown or ferruginous-tomentose underneath; ovary hairy at the top and fruit white when mature. *C. longifolia* is also allied to *C. macrophylla* in having the indumentum on the branches and peduncles of stellate-dendriform hairs and fruit white when mature. The latter, however, can easily be identified by its lamina being obtuse or rounded at the base, greyish-white tomentose beneath; corolla violet, glabrous; peduncles a little longer than the petioles and fruit glabrous.

3. **Callicarpa brevistyla** Munir, sp. nov.

Frutex erectus, ca 1.5 m altus. *Caulis* et rami cinerascento-tomentosi. *Folia* circumscriptione late elliptico-ovata vel fere orbiculata, 10-17 cm longa, 5-12 cm lata. *Pedunculi* primarii petiolo breviores. *Flores* breviter pedicellati. *Calyx* tubularis, minute 4-dentatus. *Corolla* purpurea vel malvina, 4-lobata, glabra, glandibus in dorso quoque lobi paucis, 2.5-3 (-4) mm longa. *Stamina* 4, exserta, filamentis 4-6 mm longis. *Ovarium* glabrum, glandulosum, 0.5-1 mm diametro. Stylus brevissimus, inclusus, glaber, ca 1 mm longus. *Fructus* drupa globula, 2-3 mm diametro, ubi vivus purpureus.

Type: *N. Byrnes 1309*, Mt Bundey, Northern Territory, Australia, 22.i.1969 (NT, holotype; DNA, isotype).

Description (Fig. 3)

An erect shrub of about 1.5 m. *Stem* and branches densely clothed with a grey or greyish-rusty indumentum of stellate hairs. *Leaves*: lamina broadly elliptic-ovate or almost orbicular, entire or somewhat undulate and denticulate, acuminate, ± cuneate at the base, membranous, 10-17 cm long, 5-12 cm broad, glandular and stellately greyish-pubescent-tomentose underneath, puberulous or glabrescent above when mature; petiole densely clothed with greyish-rusty stellate hairs, 1.5-3 cm long. *Inflorescence* rather lax; primary peduncle shorter than the petiole, densely tomentose, 0.5-1.3 cm long. *Flowers* shortly pedicellate, 4-merous; pedicels glandular and pubescent, 0.5-1 mm long. *Calyx* tubular, minutely 4-toothed, glandular and pubescent outside, glabrous inside, 1-1.5 mm long, ± 1 mm in diameter distally. *Corolla* purple or mauve, glabrous, with a few glands on the back of each lobe, 2.5-3 (-4) mm long; lobes broadly ovate-orbicular, obtuse, 1-1.5 mm long, ± 1 mm broad; tube 1.5-2 mm long. *Stamens* 4, exserted, inserted at the base of the corolla-tube; filaments 4-6 mm long; anthers oblong, glandular on the back, ± 1 mm long, ± 0.5 mm broad. *Ovary* globose, glabrous, glandular all over, 0.5-1 mm in diameter; style short, included, filiform, glabrous, ± 1 mm long, stigma capitate. *Fruit* globular drupe, glabrous, somewhat succulent and glandular-glutinous when fresh, 2-3 mm in diameter, purple.

Specimens examined

AUSTRALIA: NORTHERN TERRITORY: *Byrnes 1309*, Mt Bundey, 22.i.1969 (NT, holotype; DNA, isotype). *Levitt s.n.*, Angurugu, Groote Eylandt (Island), 22.iii.1972 (DNA 4438). *Levitt s.n.*, loc. cit. 10.iv.1972 (DNA 4444).

Distribution (Map 4)

C. brevistyla seems to be endemic in northern Australia where it has been recorded from Arnhem Land in the Northern Territory and from neighbouring Groote Eylandt in the Gulf of Carpentaria.

Comments

The leaves and inflorescences of *C. brevistyla* and *C. candicans* are similar in several characters, and it is, therefore, not possible to separate these taxa without flowers. In view of their similar appearance, all *C. brevistyla* collections have previously been identified as *C. candicans*.

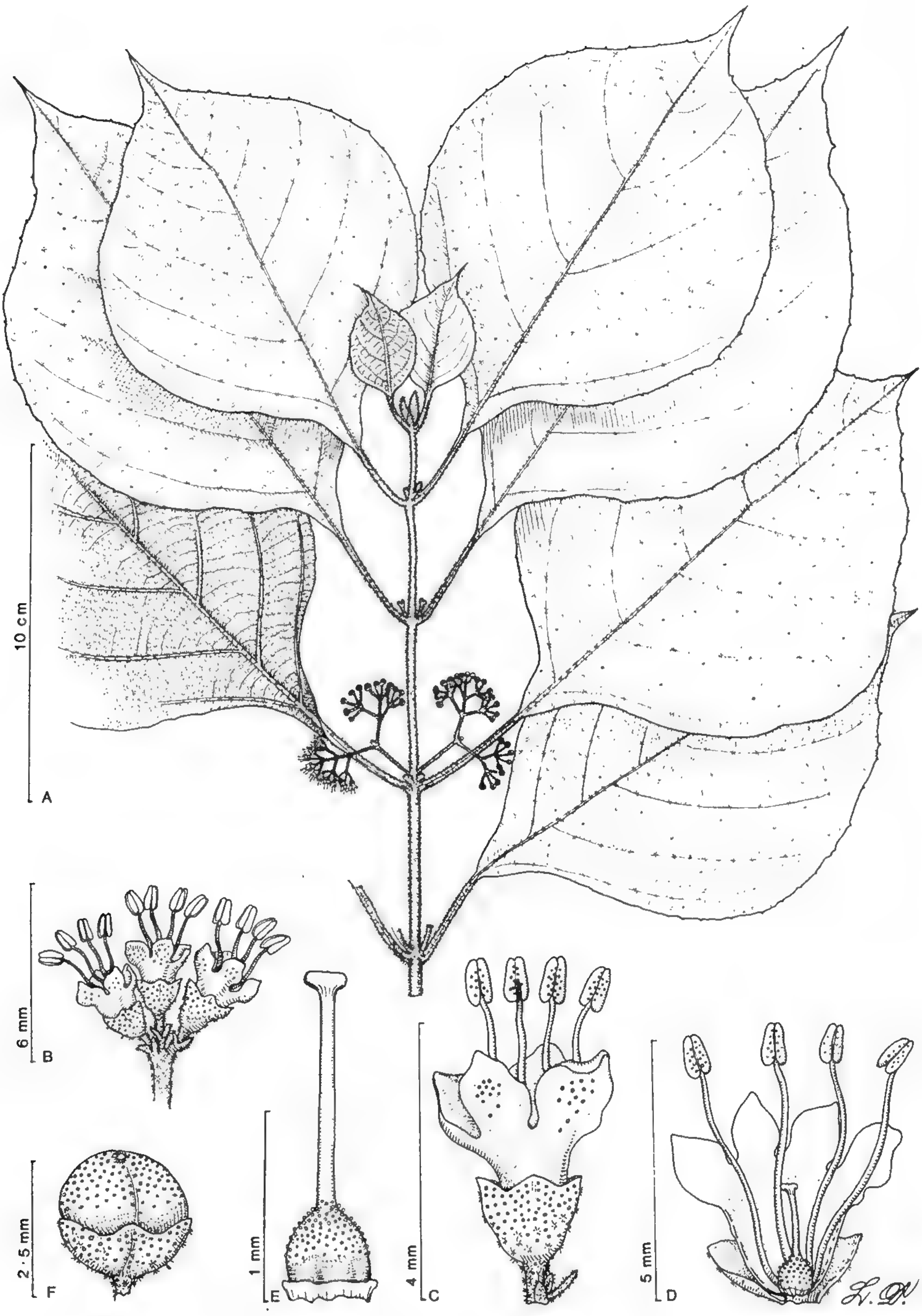


Fig. 3. *Callicarpa brevistyla* Munir (A-E, *N. Byrnes 1309*: DNA, F, *D. Levitt s.n.*, DNA 4444). A, flowering twig; B, cyme; C, flower; D, flower vertically cut open to show androecium, gynoecium and short included style; E, gynoecium; F, fruit with persistent calyx.

Affinities

C. brevistyla is closely related to *C. candicans* in its stem and leaves being covered with stellate hairs; lamina cuneate towards the base, greyish-tomentose underneath; peduncles shorter than the petioles; corolla violet, glabrous; ovary glandular, glabrous; fruit purple. However, *C. brevistyla* may easily be distinguished by its short included style of about 1 mm long. The leaf characters given in the key are helpful but not always entirely reliable.

C. brevistyla is also close to *C. longifolia* in having indumentum of stellate hairs; lamina cuneate at the base and peduncles shorter than the petioles. The latter, however, may easily be identified by its leaves being almost glabrous or slightly rusty-tomentose underneath; corolla white and pubescent outside; ovary hairy at the tip; style much longer, exserted, 4-6 mm long, and fruit white. *C. brevistyla* is endemic in northern Australia whereas *C. candicans* and *C. longifolia* are widespread in Asia and elsewhere.

4. **Callicarpa candicans** (Burm. f.) Hochr., Candollea 5 (1934) 190; Mold., Résumé Verbenac. etc. (1959) 208, 213, 241-247, 319, 355; C. Back. & Bakh., Fl. Java 2 (1965) 601; Mold., Fifth Summary Verbenac. etc. 1 & 2 (1971) 344, 404-409, 417-419, 570, 645, 971; Mold., Phytologia 2 (1971) 331.

Urtica candicans Burm. f., Fl. Ind. (1768) 197, *basionym*.

Type: "Habitat in Java",—(n.v., probably in Herb. G). Collector's name is not given in the protologue.

Callicarpa cana L., Mant. 2 (1771) 198; Vahl, Symb. Bot. Pl. 3 (1794) 12; Raeusch., Nomencl. Bot. edn 3 (1797) 37; Willd., Linn. Sp. Pl. 1 (1798) 620; Roem & Schult., Syst. Veg. 3 (1818) 94; Roxb., Fl. Ind. 1 (1820) 406; Sims, Bot. Mag. 47, N. Ser. 5 (1820) t. 2107; Blume, Bijdr. Fl. Ned. Ind. (1826) 817; Spreng., Syst. Veg. 1 (1825) 419; Roem. & Schult., Linn. Mant. 3 (1827) 1311; Decne, Nouv. Ann. Mus. Hist. nat. Par. 3rd Ser. 3 (1834) 401; Span., Linnaea 15 (1841) 330; Hassk., Cat. Pl. Hort. Bot. Bog. (1844) 136; Walp., Rep. Bot. Syst. 4 (1845) 127; Schau. in DC., Prod. 11 (1847) 643; Miq., Fl. Ind. Bat. 2 (1858) 885 & Suppl. 1 (1861) 243 & 569; Benth., Fl. Aust. 5 (1870) 56; F.-Vill., Novis. App. (1880) 158; F. Muell., Syst. Cens. Aust. Pl. 1 (1882) 103; Bail., Synop. Qld Fl. (1883) 377; C.B. Clarke in Hook. f., Fl. Br. Ind. 4 (1885) 568; Forbes, Wand. Nat. f. Malay. Arch. 2 (?1885) 226; Hemsl., Chall. Report. Bot. 1 (1885) 110 & 176; Vidal, Phan. Cuming. Philip. (1885) 134; Rev. Pl. Vasc. Filip. (1886) 208; F. Muell., Sec. Syst. Cens. Aust. Pl. 1 (1889) 173; Forbes & Hemsl., Fl. Sin. 2, J. Linn. Soc. (Bot.) 26 (1890) 252; Bail., Cat. Pl. Qld (1890) 35; Warb., Bot. Jahrb. 13 (1891) 426; Qld Fl. 4 (1901) 1174; K. Schum. & Lauterb., Fl. D. Südsee (1901) 522; Merr., Rep. Invest. Java 1902 (1903) 51; Williams, Bull. Herb. Boiss. 2nd Ser. 5 (1905) 430; King & Gamble, J. As. Soc. Beng. LXXIV, 4 (1909) 806; Fl. Mal. Penin. no. 21 (1909) 1016; Merr., Fl. Manila (1912) 401; Bail., Comp. Cat. Qld Pl. (1913) 382; Elm., Leafl. Philip. Bot. 6 (1913) 2084, 2085; Ewart & Davies, Fl. North. Terr. (1917) 237; H.J. Lam, Verbenac. Malay. Arch. (1919) 68; Merr., Enum. Philip Fl. Pl. 3 (1923) 382; Ridley, Fl. Mal. Penin. 2 (1923) 616; Heyne, Nutt. Pl. Ned. Ind. 2 edn 2 (1927) 1311; Domin, Bibl. Bot. 89 (1929) 554, fig. 179 p.p.; Gard., Enum., Pl. Aust. Occ. 3 (1931) 112; Mold., Fedde Repert. Sp. Nov. Reg. Veg. 40 (1936) 109; Résumé Verbenac. etc. (1959) 242, pro syn.; Prain, Beng. Pl. 2, rep. edn (1963) 618; Beard (ed.), W. Aust. Pl. edn 1 (1965) 91; Burkill, Dict. Econ. Prod. Malay Penin. 1 (1966) 407; Mold., Fifth Summary Verbenac. etc. 1 (1971) 406, pro syn.; Green, Cens. Vasc. Pl. West. Aust. (1981) 89.

Type: *J.G. König s.n.*, East Indies, Java (n.v.). Not on the microfiche of Linnaean Herbarium at LINN or S.

C. tomentosa (L.) Lam. auct. non L.: Lam., Encycl. Meth. Bot. 1 (1783) 562 p.p. excl. basionym *Tomex tomentosa* L.; Vahl, Symb. Bot. Pl. 3 (1794) 12; Raeusch., Nomencl. Bot. edn 3 (1797) 37.

C. americana auct. non L.: Lour., Fl. Cochinch. edn 1, 1 (1790) 70; Vahl, Symb. Bot. Pl. 3 (1794) 12.

C. macrocarpa Raeusch., Nomencl. Bot. edn 3 (1797) 37, nom. nud.

Type: "Ind. Orient" (n.v.).

C. bicolor auct. non Juss.: Schau. in DC., Prod. 11 (1847) 642 (quoad Cuming pl. exs. n. 1283); Miq., Fl. Ind. Bat. 2 (1858) 889; Merr., Phil. J. Sc. Bot. 1, Suppl. 1 (1906) 121.

C. adenanthera R. Br., Prod. Fl. Nov. Holl. (1810) 513; Roem. & Schult., Syst. Veg. 3 (1818) 98; Spreng., Syst. Veg. 1 (1825) 420; Walp., Rep. Bot. Syst. 4 (1845) 129.

Type: *R. Brown s.n.*, Queensland, 1802-05 (BM, K—syntypes!).

C. heynii Roth in Roem. & Schult., Syst. Veg. 3 (1818) 96; Roth, Nov. Pl. Sp. (1821) 82; Blume, Bijdr. Fl. Ned. Ind. (1826) 819; Spreng., Syst. Veg. 1 (1825) 420; Roem. & Schult., Linn. Mant. 3 (1827) 53; Span., Linnaea 15 (1841) 330; Walp., Rep., Bot. Syst. 4 (1845) 128; Zoll. & Mor., Syst. Verz. Zoll. (1846) 53.

Type: *B. Heyne s.n.*, "In India Orientali", undated (n.v.).

C. dentata auct. non Roth: Roxb., Wall. Cat. (1829) No. 1834, p.p.

C. rheedii Kostel., Alleg. Med.-Pharm. Fl. 3 (1834) 829.

Type: *Rheed s.n.*, Malabar, India.—(n.v.)

C. latifolia Zippel ex Span., Linnaea 15 (1841) 330, nom. nud., Pro syn.

C. sumatrana Miq., Fl. Ind. Bat. 2 (1858) 886, basionym of *C. cana* L. var. *sumatrana* (Miq.) H.J. Lam and *C. candicans* (Burm. f.) Hochr. var. *sumatrana* (Miq.) Moldenke.

Type: *Teysman s.n.*, Sumatra, in Padang, langs de wegen,—(n.v.).

C. longifolia auct. non Lam.: Miq., Fl. Ind. Bat. 2 (1858) 887 p.p. quoad syn. *C. adenanthera* R. Br.

C. cana L. var. *typica* H.J. Lam, Verbenac. Malay. Arch. (1919) 70.

Type: *Elbert 20467 & Forbes 1252*, Java,—(n.v.). Collections by others from different localities were also cited.

C. cana L. var. *sumatrana* (Miq.) H.J. Lam, loc. cit. p. 71.

Type: As for *C. sumatrana* Miq.

C. cana L. var. *longifolia* H.J. Lam, loc. cit. p. 72.

Type: *Gorontalo s.n.*, Herb. L. no. 908. 266-1231 & 1232, Celebes, 18.x.1911 (n.v.). Syntypes from the Philippines by *Reillo 19265*, *Raymundus 189* and *Ledermann 14126* were also cited.

C. cana L. var. *latifolia* H.J. Lam f. *typica* H.J. Lam, loc. cit. 72.

Type: *Elbert 736 & 1992*, Mt Rindjani, Lombok, Feb. & April 1909 (n.v.). Five more collections by others from different localities were cited with the protologue.

C. cana L. var. *latifolia* H.J. Lam, f. *pentamera* H.J. Lam, loc. cit. p. 73.

Type: Herb. L nos. 908. 265-1108 and 1445 (n.v.). These two specimens are without name of collector or locality.

C. cana L. var. *dentata* H.J. Lam, loc. cit. p. 73.

Type: *Elbert 3505*, Sumbawa, 3.xii.1909 (n.v., syntype). *Zippel s.n.*, sub Herb. L. no. 908. 266-13 (n.v. syntype).

C. cana L. var. *integrifolia* H.J. Lam, f. *typica* H.J. Lam, loc. cit. p. 74.

Type: *Kraemer 36 & Volkens 210*, Caroline Island, 16.xii.1899 (n.v.). Four more collections by others from different localities were cited with the protologue.

C. cana L. var. *integrifolia* H.J. Lam f. *glabriuscula* H.J. Lam, loc. cit. p. 74.

Type: *Weber s.n.*, sub Herb. L no. 908. 267-916, Saleyer Island,—(n.v.). Two other collections were also cited with the above syntype.

C. candicans (Burm. f.) Hochr. var. *sumatrana* (Miq.) Mold. Phytologia ......?; Résumé Verbenac etc. (1959) 247.

Type: As for *C. sumatrana* Miq.

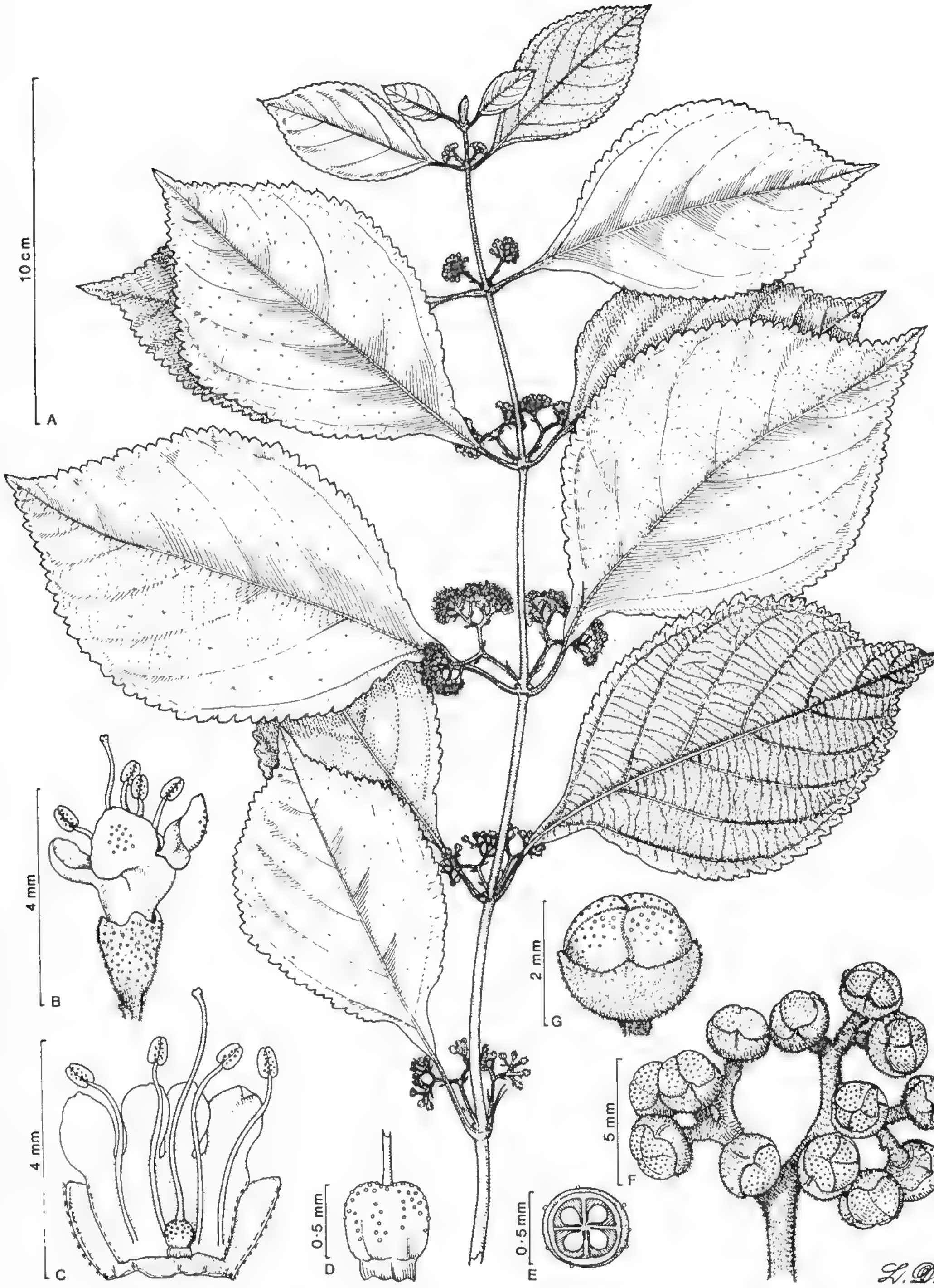


Fig. 4. *Callicarpa candicans* (Burm. f.) Hochr. (A-E, *N. Byrnes 1235*: BRI; F-G, *C. Dunlop 3115*: DNA). A, flowering branch; B, flower; C, flower vertically cut open to show androecium and gynoecium; D, ovary; E, transverse section of ovary; F, infructescence; G, fruit with persistent calyx.

Description (Fig. 4)

A shrub or small tree 1-4 (-6) m tall. *Stem* (young) and branches greyish-brown-tomentose. *Leaves*: lamina very variable in form, elliptic-oblong, lanceolate, ovate-lanceolate or ovate-rotundate, cuneate towards the base, shortly acuminate at the apex, serrate-dentate along the margins, (7-) 10-20 cm long, (2.5-) 4-9 (-11) cm broad, glandular and densely greyish-white- or yellowish-grey stellate-tomentose beneath, stellate-pubescent above when young, later glabrous except on the nerves; petiole stellate-tomentose, 0.6-3 (-4) cm long. *Inflorescence* stellate-tomentose; primary peduncles shorter than the petioles, 0.5-1 cm long. *Flowers* sub-sessile, 4-merous. *Calyx* minutely 4-toothed or almost truncate, glandular and stellate-hairy outside, glabrous inside, 1-1.5 mm long, ± 1 mm in diameter at the top. *Corolla* mauve or violet, glabrous, with a few glands on the back of each lobes, 3-3.5 mm long; lobes broadly ovate or almost orbicular, obtuse, 1-1.5 mm long, nearly as broad at the base; tube ± 2 mm long, 1 mm in diameter at the top. *Stamens* exserted; filaments 4-5 mm long; anthers oblong, glandular on the back along the connective, ± 1 mm long, 0.5 mm broad. *Ovary* globose, glabrous, glandular all over, ± 0.5 mm in diameter; style exserted, glabrous, 5-6 mm long, stigma capitate. *Fruit* a depressed-globular almost succulent drupe, mauve, purple, or deep dark red, glabrous, glandular, ± 2 mm in diameter.

Representative specimens collections seen: Australian 59, non-Australian 25).

AUSTRALIA: QUEENSLAND: *Armit 477*, Sutherland Creek, undated (MEL 97701); *Brass 280*, Settlement Creek, Feb. 1923 (BRI, CANB, NSW); *Byrnes* 3201, Lizard Island, 8.v.1975 (BRI); *Cameron 20137*, Prince of Wales Island, 13.ii.1975 (QRS 2 spec.); *Dallachy s.n.*, Port Denison,—(MEL 97614-5); *Hubbard & Winders 6736*, Chillagoe, 22.i.1931 (BRI, K); *Hyland 9934*, Jervoise Holding, 18° 54′ S, 144° 43′ E, 31.v.1979 (QRS); *Persieh 693*, Endeavour River, 1882 (MEL); *Webb & Tracy 10177*, 6.4 km N of Mungana, 31.v.1970 (BRI); *K.J. White 1174*, Cape York, 11° 00′ S, 142° 00′ E, Nov. 1955 (BRI).

NORTHERN TERRITORY: *Byrnes 1235*, Green Ant Creek, East Spring, 13° 32′ S, 131° 14′ E, 18.xii.1968 (BRI, NT); *Craven 3556*, McArthur River area, 16° 27′ S, 136° 10′ E, 31.i.1976 (A, CANB, L, NT); *Dunlop 3115*, Wagait Reserve, 13° 12′ S, 130° 40′ E, 16.i.1973 (BRI, CANB, DNA, K, MO, NT); *F. Mueller s.n.*, Victoria River, May, 1856 (MEL 97610).

WESTERN AUSTRALIA: *Easton 1008*, near Artesian Range, Sept. 1923 (PERTH); *Fitzgerald 616*, Devil's Pass, Napier Range, May, 1905 (PERTH); *Fitzgerald s.n.*, May River, May, 1905 (NSW); *Froggat 40*, King Sound, Derby, 1887 (MEL 97609).

NEW GUINEA: *Bradtke 232 & 376*, Duke of Yorke Islands, July, 1917 (BRI); *Coode & Katik NGF 40110*, Karu, Kaving subdistrict, New Ireland, 03° 29′ S, 152° 14′ E, 12.i.1969 (BRI, LAE, A, BOG, CANB, K, L); *Henty & Frodin NGF 27280*, Arawe, Kandrian subdistrict, New Britain, 06° 10′ S, 149° 03′ E, 20.iii.1966 (BRI, A, CANB, K, L, LAE, NY); *Wiakabu & Kauning LAE 73313*, PNG & W. Irian border near Vanimo, 02° 37′ S, 141° 00′ E, 19.ix.1977 (BRI, A, CANB, E, K, L, LAE, UPNG).

TIMOR: *Kooy 328*, South Central Area, Noetako (Amantun), 29.i.1966 (BRI, L).

JAVA: *Koorders 21928*, Banjumas, 2.i.1896 (BRI, BOG); *Meer s.n.*, Bay of Djakarta, 20.v.1957 (CANB, L).

KALIMANTAN: *Teysmann s.n.*, "Tiga nemin, Lampongs",—(MEL 97757).

SUMATRA: *Junghuhn 5*, Padang, undated (L).

PHILIPPINES: *Cuming 1283*, Philippine Isl.,—(MEL 97754).

VIETNAM: *Squires 188*, near Hue, Jan.-May, 1927 (MEL).

GUAM: *Shmull 7*, Yona, 31.i.1962 (L).

HAINAN: *Hai Ngan & Lei 155*, Mei Maan, Ching Mai district, 21.x.1932 (L).

INDIA: *Hooker s.n.*, Ind. Orient, loc. incert., 1830 (MEL 97756).

Distribution (Map 4)

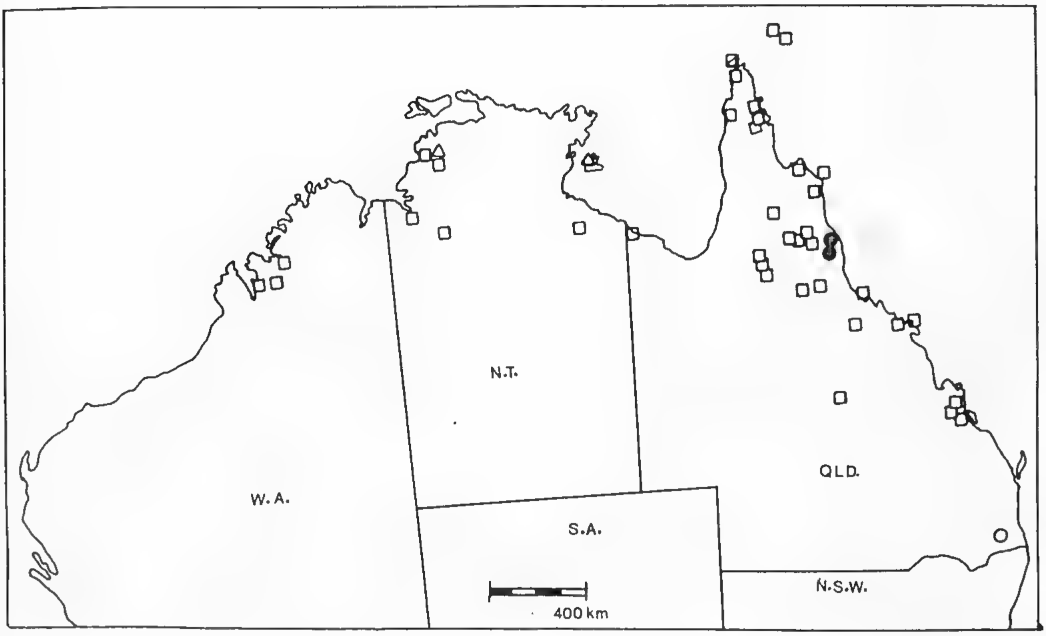
C. candicans is widely distributed in tropical areas of Queensland, Northern Territory and Western Australia. In Queensland it grows in the coastal areas from Rockhampton northwards to the tip of Cape York Peninsula. It has also been recorded from several off-shore Islands of the State. In the Northern Territory, one locality is

along the McArthur River near the Gulf of Carpentaria and all the rest to the south-west of Darwin between Daly River and Victoria River. It is very likely that this species may also occur in Arnhem Land, but so far we have no record from that area. The Western Australian localtiies are in the south-western part of the Kimberlies where it has been recorded from north-east of Broome near King Sound and Collier Bay. Further exploration may reveal its presence in other parts of the Kimberley region.

Collections from overseas have been examined from Eastern India, Vietnam, Hainan, Guam and most parts of Malesia. Lam (1919) recorded it in several parts of Malesia except Borneo and New Guinea. According to Moldenke (1971), this species also occurs in Southern China, Laos and Thailand.

Comments

A range of leaf shape and density of hairs on the lamina has been observed within this species. There is also variation, even in one collection, in petiole-length and in the number of secondary veins. It is, therefore, necessary to examine a range of collections from different localities to establish the general shape and leaf-size. The young leaves are generally densely hairy all over, but in mature leaves the hairs on the adaxial surface gradually diminish and the lamina often becomes almost glabrous. Such changes are also noticed in several other *Callicarpa* species but they are apparently more pronounced in *C. candicans*. Lam (1919) seems to have accepted slight differences in leaf-shape, size and length of petiole as stable characters and on this basis he created six varieties and four forms within this species. These forms are so inconsistent and merge into each other so gradually that no purpose is served in retaining them. During present investigations, all of these infraspecific taxa have been found identical with the typical variety, and have, therefore, been placed in synonymy.



Map 4. *C. brevistyla* △; *C. candicans* □; *C. macrophylla* ○; *C. caudata* ●

Charles O. Frake's collection no. PNH 36163 (CANB) from Mindanao has been identified as this species. Amongst all the available *Callicarpa* specimens, this collection seems nearest to *C. candicans* but differs in having much longer pedicels, filaments and style, and oblong-elliptic leaves.

In the protologue of *C. cana* the type locality is given: "Habitat in Java", but there is no mention of collector's name. According to Moldenke (1936), however, "the type of this Old World species was collected by J.G. Köning in eastern India". During present studies, the type was not found on the microfiche of Linnaean herbarium at LINN or S.

Lam's var. *latifolia* f. *pentamera* has been erroneously recorded by Moldenke (1959, 1971) as "var. *latifolia* f. *pentandra*".

According to Burkill (1966), "the tender leaves are boiled and the decoction is drunk for abdominal troubles ...... In Java a decoction is used for bringing on menses, and the leaves are used for poulticing wounds and boils ...... It is one of the species ...... used in the Philippines Islands for stupifying fish; yet after drying, it is also a bait for prawns".

In the National Herbarium of Victoria, one of Armit's collection (MEL 97701) has a locality and the collection no. "477" and the other (MEL 97618) only the year of collection "1884". In view of great similarity between the two specimens, it seems probable that both specimens belong to the same collection.

Affinities

C. candicans is closely allied to *C. brevistyla*, *C. longifolia* and *C. macrophylla*. For details see "affinities" under these species.

According to Moldenke (1936), this species has been "most frequently (especially in old works) compared with *C. lanata* L. and *C. americana* L., it seems instead to be most closely related to *C. erioclona* Schau".

5. **Callicarpa macrophylla** Vahl, Symb. Bot. Pl. 3 (1794) 13, t. 53.

Raeusch., Nom. Bot. edn 3 (1797) 37; Willd., Linn. Sp. Pl. 1 (1798) 620; Roem. & Schult., Syst. Veg. 3 (1818) 94; Roxb., Fl. Ind. 1 (1820) 408; Spreng., Syst. Veg. 1 (1825) 420; Roem. & Schult., Linn. Mant. 3 (1827) 53; Walp., Rep. Bot. Syst. 4 (1845) 127; Schau. in DC., Prod. 11 (1847) 644; Benth. in Hook., J. Bot. & Kew Gard. Misc. 5 (1853) 135; Benth., Fl. Hongk. (1861) 270; Brandis, For. Fl. NW. & Centr. Ind. (1874) 368; Kurz, For. Fl. Br. Burma 2 (1877) 274; Gamble, Man. Ind. Timb. edn 1 (1881) 282-83 & 503; C.B. Clarke in Hook. f., Fl. Br. Ind. 4 (1885) 568, excl. var. *griffithii* & var. *sinensis*; Maxim., Bull. Acad. Sc. St. Petersb. 31 (1887) 75; Maxim. in Mel. Biol. 12 (?1888) 505; K. Schum., Bot. Jahrb. 9 (1888) 220; K. Schum. & Hollr., Fl. Kais. Wilh. Land (1889) 118; Forb. & Hemsl., J. Linn. Soc. (Bot.) 26 (1890) 254; Warb., Bot. Jahrb. 13 (1891) 426; K. Schum. & Lauterb., Fl. D. Südsee (1901) 522; Collett, Fl. Siml., rep. edn (1921) 380; B. Leeuwen, Faber & Smith, Bull. Jard. Bot. Ser. 3, 4 (1922) 284; Junell, Symb. Bot. Ups. 4 (1934) 81, 82, fig. 132; Mold., Fedde Repert. Sp. Nov. Reg. Veg. 40 (1936) 104; Parker, For. Fl. Punjab edn 3 (1956) 393; Dakkus, List Pl. Cult. Hort. Bot. Bog. edn 2 (1957) 42; Mold., Résumé Verbenac. etc. (1959) 155, 157-160, 165, 168, 174, 177, 200, 242-43, 245, 247; Haines, Bot. Bihar & Orissa 2, rep edn (1961) 744; Prain, Beng. Pl. 2, rep. edn (1963) 618; C. Back. & Bakh. f., Fl. Java 2 (1965) 601; Mold., Fifth Summary Verbenac. etc. 1 & 2 (1971) 267, 269-72, 282, 286, 293-94, 335, 405-08, 410, 417-19; Phytologia 21 (1971) 214, 336, 376; Stewart, Ann. Cat. Vas. Pl. W. Pak & Kash. (1972) 605, fig. 2, F-H; Jafri & Ghafoor, Fl. W. Pak. no. 77 (1974) 20.

Type: *J.G. König s.n.*, Eastern India,—(C, microfiche!).

C. incana Roxb., Fl. Ind. 1 (1820) 407.

Type: *Roxburgh s.n.*, Bengal, India,—(K).

C. roxburghii Wall., Cat. (1829) no. 1833, nom. nud., Walp., Rep. Bot. Syst. 4 (1845) 127; Schau. in DC., Prod. 11 (1847) 640.

Type: *N. Wallich 1833*, Bengal, India,—(K).

C. cana auct. non L.: Gamble, Darj. Pl. List (1878) 60; Man. Ind. Timb. (1881) 283.

C. dunniana Lev., Fedde Repert. Sp. Nov. Reg. Veg. 9 (1911) 456.

Type: *J. Seguin 2439*, Hoang-Ko-Chou, 20.vi.1898 (n.v.); *Jos. Esquirol 869*, Long-chan, June, 1960 (n.v.).

Description (Fig. 5)

A shrub or small tree 3-5 mm high. *Stem* and branches densely covered with a greyish tomentum of stellate hairs. *Leaves*: lamina ovate or narrowly elliptic to oblong-lanceolate, acuminate, cuneate, obtuse or rounded at the base, crenate-serrate or crenate-dentate, 10-35 cm long, 2-18 cm broad, mature glabrescent and rugose above or with very numerous stubble-like small hairs, densely greyish-white stellate-tomentose beneath; petiole 1-2 (-2.5) cm long, densely floccose-tomentose. *Inflorescence* densely stellate-hairy; primary peduncles equal to or a little longer than the petioles, 1-2.5 (-3) cm long. *Flowers* on short slender pedicels; pedicel gland-dotted, tomentose, ± 1 mm long. *Calyx* minutely 4-denticulate, 1-1.5 mm long, glandular outside, with coarse stellate-hairs at the base, glabrous inside. *Corolla* violet or lilac, thinly hairy or almost glabrous with yellow glandular dots outside, glabrous inside, 2.5-3.5 mm long; lobes 1-1.5 mm long, obtuse or rounded; tube 2-2.5 mm long. *Stamens* exserted, inserted near the base of the corolla-tube; filaments 4-6 mm long; anthers oblong, ± 0.7 mm long, 0.4-0.5 mm broad, glandular along the connective. *Ovary* globose, glabrous, densely glandular, 0.5-1 mm in diameter; style exserted, glabrous, 5-8 mm long, stigma capitate. *Fruit* globular, ± 2 mm in diameter, glabrous, glandular, smooth, white.

Specimens examined

AUSTRALIA: QUEENSLAND: *Eaves s.n.*, Bremer River, undated (MEL 97743).

NEW GUINEA: *?Bradtke 298*, Duke of York Island, undated (BRI).

BURMA: *McKee 6006*, Hsenwi, 7.i.1958 (CANB); *McKee 6193*, Nyaungshwe, 13.v.1958 (CANB).

INDIA: *Falconer 748*, loc. incert., Herb. East. Ind. Co., distributed 1869 (K, L).

Distribution (Map 4)

The first and the only Australian record of *C. macrophylla* is made here from south-east of Brisbane in Queensland. Moldenke (1971) recorded it from the Mascarene Islands, Bangladesh, Nepal, India, Southern China, Hong Kong, Burma, Thailand, West Irian and Papua New Guinea. So far, its presence in Malaysia, the Philippines, Timor and all parts of Indonesia (excepting West Irian) is unknown. According to Backer & Bakhuizen (1965), it is "cultivated as an ornamental" in Java. Moldenke (1971) listed it as cultivated in Argentina, Belgium, Brazil, California in the U.S.A. and Cuba. From outside Australia, the present author has seen reliably identified collections only from Burma and India.

In the case of the single specimen from Queensland it could not be ascertained whether the plant occurs there naturally or whether the material was obtained from a cultivated tree.

Comments

Moldenke's (1971) record from the Mascarene Islands is not only without any locality but away from the main distribution area of this species. It seems that he probably saw a specimen from cultivation introduced as an ornamental. In "Hortus Mauritianus", Bojer (1837) recorded it as "Pat Inde orientale. Cult au jardin du Roi, Pampl. Arbrisseau. Fl. Mars, Mai". According to Moldenke "this species is native from China southward into Nepal, Bhutan, India, Burma, and Hong Kong, and east to New Guinea. It has been introduced in Reunion and Madagascar and is widely cultivated

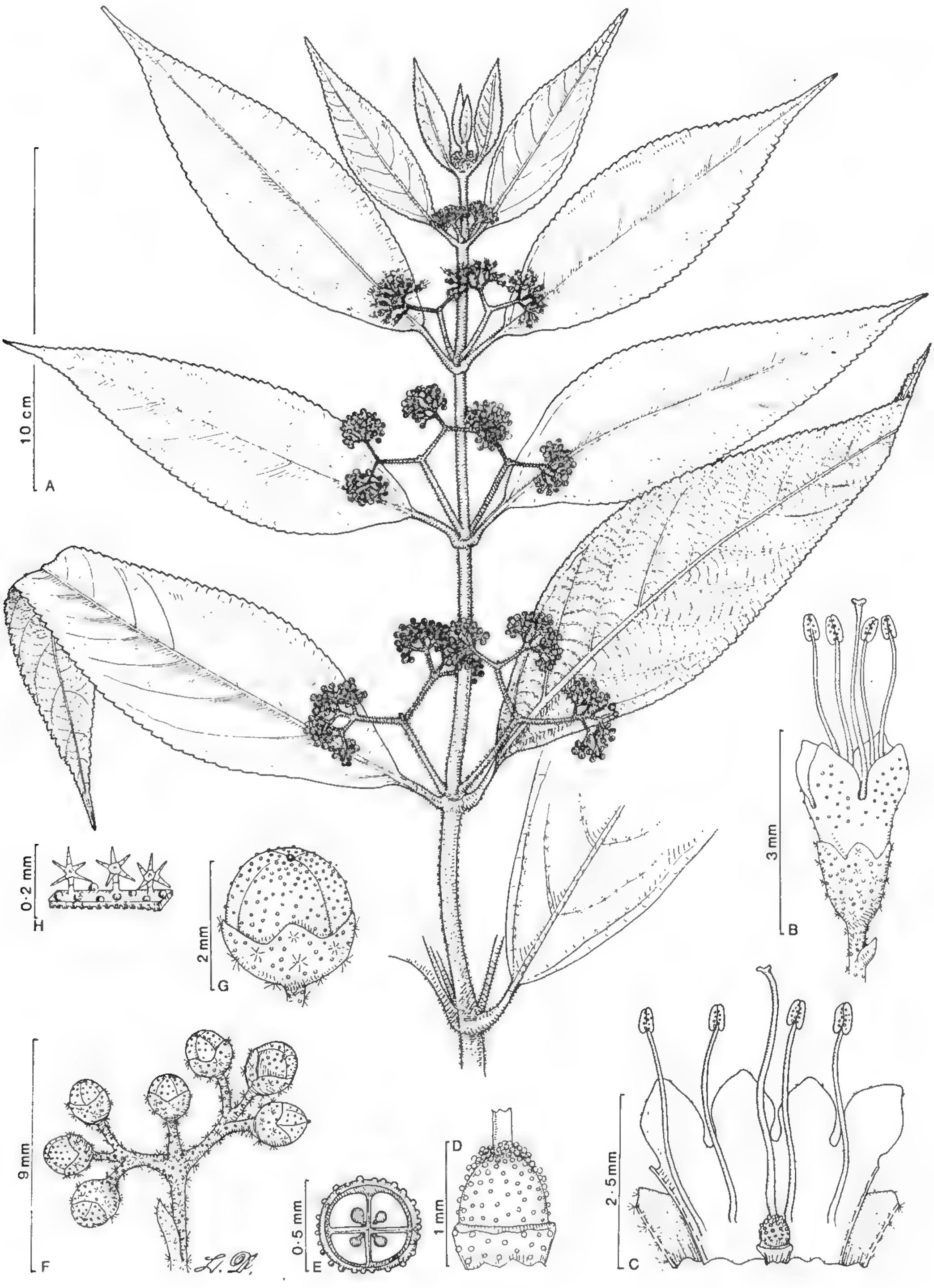


Fig. 5. *Callicarpa macrophylla* Vahl (A & F-H, *Eaves s.n.*: MEL 97743; B-E, *M.S. McKee 6193*: CANB). A, flowering branch; B, flower; C, flower vertically cut open to show androecium and gynoecium; D, ovary; E, transverse section of ovary; F, infructescence; G, fruit with persistent calyx; H, calyx-hairs.

elsewhere". According to Forbes & Hemsley (1890) it is "widely spread in Northern and Eastern India".

The corolla-colour is described as pink, red, purple, purplish-pink, blue, violet or reddish-purple, depending upon the interpretation and definition of colour by different collectors.

According to some Indian authors, it is "cultivated as a hedge plant in gardens, and the seed-paste being used by some for mouth ulcers in Uttar Pradesh". It is also said to be "used in the preparation of a medicine used for injuries" in Kwangsi, China, and in Hazara, Pakistan "the heated leaves are used to cure the rheumatic pains".

Affinities

Amongst all Australian *Callicarpa*, *C. macrophylla* seems nearest to *C. candicans* in its stem and inflorescence being stellate-tomentose; leaves densely greyish-white tomentose underneath; corolla mauve or lilac, glabrous; ovary glabrous and glandular all over. However, *C. macrophylla* may easily be distinguished by its lamina being obtuse or rounded at the base; peduncles a little longer than the petioles, and fresh mature fruit of white colour. The lamina in *C. candicans* is cuneate towards the base and the fresh mature fruit of purple colour. *C. macrophylla* is also close to *C. caudata* in having its lamina obtuse or rounded at the base; peduncles longer than the petioles and corolla violet and glabrous. The latter, however, differs in its stem and peduncle being covered chiefly with simple septate hairs; lamina elongated towards the apex into a caudate tip, ferruginous tomentose underneath, and fruit "pink" coloured.

6. **Callicarpa caudata** Maxim., Bull. Acad. Sc. St. Petersb. 31 (1887) 76; Maxim. in Mel. Biol. 12 (?1888) 506; Merr., Philip. J. Sc. (Bot.) 2 (1907) 299; Elm., Leafl. Philip. Bot. 3 (1910) 862; Merr. & Merritt, Philip. J. Sc. (Bot.) 5 (1910) 380; H.J. Lam, Verbenac. Malay. Arch. (1919) 59; Merr., Enum. Philip. Fl. Pl. 3 (1923) 283; White, Proc. Roy. Soc. Qld 34 (1923) 50; Elm., Leafl. Philip. Bot. 10 (1939) 3860; Mold., Résumé Verbenac. etc. (1959) 168, 182, 194, 197, 198, 200, 242; Phytologia 14 (1966) 144; Phytologia 21 (1971) 33, 108, 225, 233-35, 240, 332; Fifth Summary Verbenac. etc. 1 & 2 (1971) 314, 321, 329, 331, 335, 339, 406-07, 414.

Type: *Cuming 1095*, Philippines,—(n.v.). Probably in Herb. PNH.

C. caudata Maxim. var. *magna* H.J. Lam, Verbenac. Malay. Arch. (1919) 60.

Type: *Elmer 11333*, Todaya (Mt Apo), Davao, Mindanao, Philippines, Aug. 1909 (n.v.).

C. pedunculata auct. non R. Br.: Beer & H.J. Lam, Blumea 2 (1936) 222 (quoad spec. *L.J. Brass 5520*).

Description (Fig. 6)

A branched shrub to 4 m tall. *Stem* and branches glandular, densely clothed with whitish-yellow or ferruginous tomentum of simple septate hairs. *Leaves*: lamina narrowly lanceolate, rounded, truncate or cordulate at the base, long tapering caudate towards the apex, membranous, dentate, 8.5-20.5 cm long, (2-) 3-5 (-6) cm broad, reddish-yellow glands on both surfaces, pubescent above with simple septate hairs, densely tomentose beneath with ferruginous stellate-dendriform hairs, sometimes intermixed with simple hairs; petiole 0.3-1.5 cm, glandular and floccose-tomentose with ferruginous simple hairs. *Inflorescence* ferruginous-tomentose; primary peduncles longer than the petioles, tomentose, 0.5-2 (-2.5) cm long. *Flowers* pedicellate; pedicels ± 1 mm long, glandular and tomentose. *Calyx* cup-shaped, minutely 4-toothed, glandular and with long simple hairs outside, glabrous inside, 1-1.5 mm long, ± 1 mm in diameter

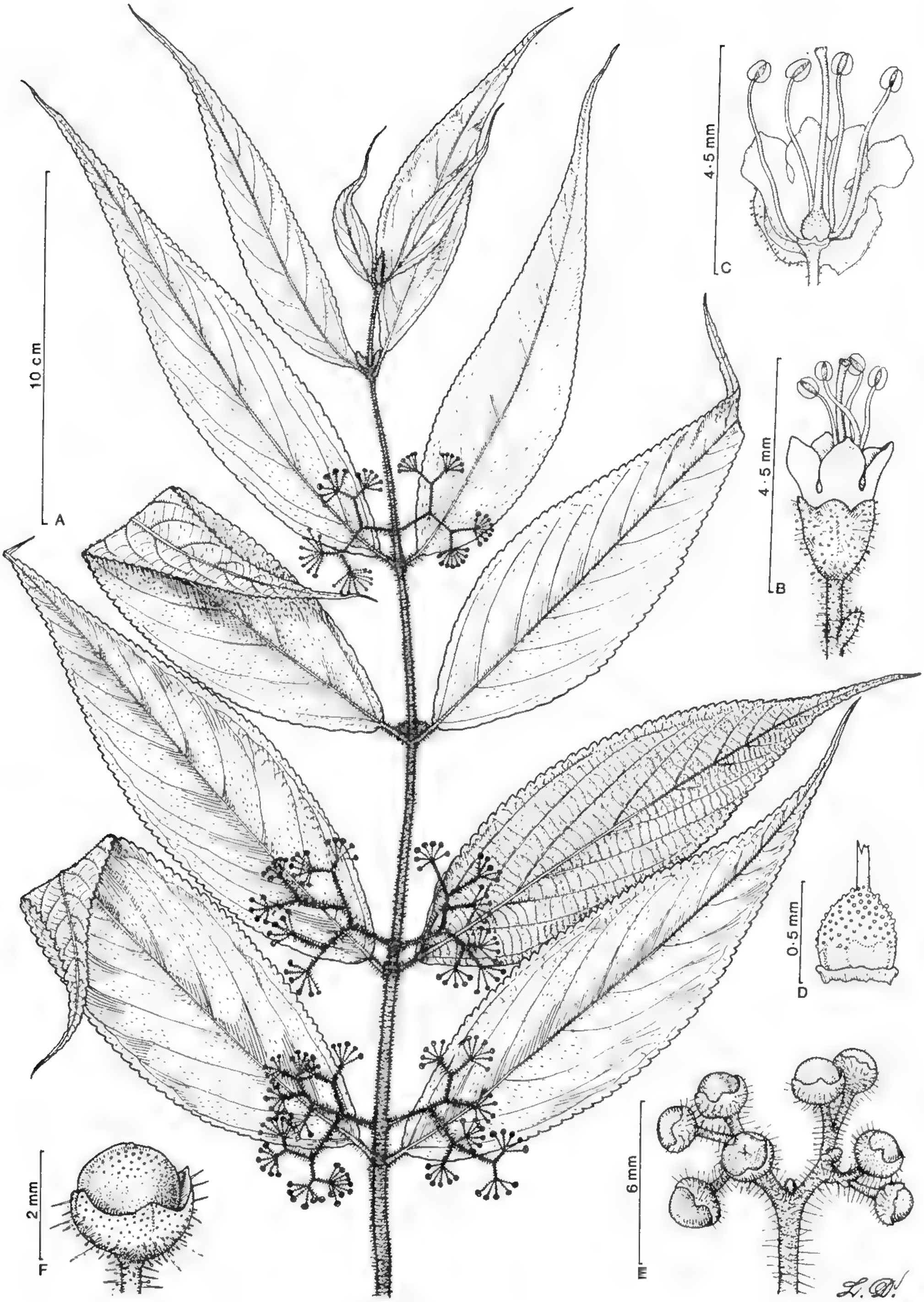


Fig. 6. *Callicarpa caudata* Maxim. (A-F, *V.K. Moriarty 2538*: QRS). A, flowering twig; B, flower; C, flower vertically cut open to show androecium and gynoecium; D, ovary; E, infructescence; F, fruit with persistent calyx.

distally. *Corolla* mauve, glabrous all over, ± 2 mm long; lobes broadly ovate or almost orbicular, obtuse, ± 1 mm long; tube dilated upwards, ± 1 mm long, about the same in diameter at the top. *Stamens* exserted, inserted near the base of the corolla-tube; filaments 3-3.5 mm long; anthers glandular along the connective, ± 0.5 mm long. *Ovary* globose, glandular all over ± 0.5 mm in diameter; style exserted, filiform, glabrous, ± 4 mm long, stigma knobby or capitate. *Fruit* globular, glabrous, glandular, "pink", ± 2 mm in diameter.

Specimens examined (collections seen: Australian 3, non-Australian 32)

AUSTRALIA: QUEENSLAND: *Berthoud s.n.*, Johnstone River, northern Queensland, Dec. 1882 (MEL 97700). *Bancroft s.n.*, loc. cit., Cook district,—(BRI 261552). *Moriarty 2538*, S.F. 675, 9 km WSW of Gordonvale, 25.xi.1978 (QRS).

NEW GUINEA: *Barker LAE 67711*, Telefomin subdist., West Sepik Dist., Busilmin airstrip, Lat. 5° 00′ S, Long. 141° 05′ E, 5.v.1975 (BRI, LAE, A, CANB, E, K, L); *Brass 5520*, Mafulu, Central Division, Sept.-Nov., 1933 (BRI, NY); *Brass 31563*, Mt Michael, Eastern Highlands, 12.ix.1959 (CANB, NY); *Carr 13163*, Boridi, Papua, 15.ix.1935 (CANB 2 spec.); *Christensen W142*, Manin Valley, Hagen subdist. Western Highlands, 05° 45′ S, 144° 20′ E, 21.xi.1973 (BRI, LAE, L); *Clarke ANU 9508*, Tsuwenkai, Jimmi, West Highlands, 05° 30′ S, 144° 45′ E, 18.ii.1970 (CANB 2 spec.); *Hartley 12051*, 6.4 km SE of Sassaura, Eastern Highlands, 146° 00′ E, 06° 24′ S, 17.vii.1963 (BRI, CANB); *Hartley 13039*, between Kuputivava and Omoretu, Goilala sub-district, Papua, 13.ii.1964 (BRI, CANB); *Hoogland & Pullen 5328*, Minuma village, upper Asaro Valley, Goroka subdistrict, 15.vi.1956 (BRI, CANB, LAE, MEL, A, BM, BO, BISH, G, K, PNH, US); *Kanis 1203*, E of Opanabu village, along Suono River, ± 149° 42′ E, 10° 01′ S, 11.vii.1969 (CANB, 2 spec., LAE, A, L, K); *Millar 17543*, Zatarl, SE of Boana, 06° 25′ S, 146° 60′ E, 27.ii.1963 (BRI, CANB, LAE); *Paijmans 1348*, 2 km S of Kundiawa, Chimbu District, 20.iv.1971 (CANB); *Paijmans 1398*, 25 km E of Minj, Kerowagi subdistrict, 27.iv.1971 (CANB); *Pullen 8048*, Bonenau village, Baniara subdistrict, 18.viii.1969 (CANB, 2 spec. LAE, L). *Robbins 2892*, Lai Valley, near Wapenamanda, Western Highlands, 6.vii.1960 (CANB); *Sayers N.G.F. 21499*, Moro, Saidor subdist., 25.xi.1964 (BM, CANB, L); *Schodde 1353*, above Kiburu, Mendi Valley, Southern Highland, Papua, 28.vi.1961 (BRI, CANB 2 spec., A, BM, L, LAE); *Schodde 4785*, ca 1.6 km E of Aselei, Morobe district, 2.iv.1966 (A, CANB 2 spec., K, L, LAE); *Versteegh B.W.3056*, Biak, Arupa, Wissel Lake Region, 23.iii.1955 (CANB); *Vink 16438*, Nona River, Kubor Range, W.A., 29.viii.1963 (CANB, L); *Wheeler ANU 6230*, 16 km SE of Hagen, W.H. July, 1966 (CANB 2 spec., LAE); *White 455*, Mafulu, July-Aug., 1918 (BRI); *Womersley 4323*, Nondugl, W.H., April, 1951 (BRI, CANB, LAE).

SOLOMON ISLANDS: *Kajewski 2420*, Guadalcanal Island, Berande River, Bau, 7.i.1930 (BRI).

PHILIPPINES: *Merrill 1727*, Benguet subprovince, Luzon, May, 1914 (BRI, PNH); *Mendoza 1099*, Mayon Volcano, Albay Prov., Luzon, 29.v.1953 (L).

INDONESIA (Moluccas): *Beguin 1229*, Ternate Island, 17.xii.1920 (L).

Distribution (Map 4)

The first Australian records of *C. caudata* were collected from northern Queensland where it has been found south of Cairns. Lam (1919) recorded it only from the Philippines, but Moldenke (1959, 1971) gave its distribution from China, the Philippines, Celebes, Timor, Moluccan Islands, New Guinea and the Bismark Archipelago. The present author has been able to confirm its occurrence only in the Philippines, Moluccan Islands, New Guinea and the Solomon Islands.

Comments

Lam (1919) described four varieties under this species, namely var. *magna*, var. *typica*, var. *glabriuscula* and var. *simplicipuberula*. Moldenke (1971) recognized two of these varieties viz.: var. *magna* and var. *typica* as convarietal with the typical variety *caudata* and transferred var. *glabriuscula* as a synonym under *C. dolichophylla* Merrill, and var. *simplicipuberula* under *C. merrillii* Moldenke. During present investigations, all Australian collections of *C. caudata* were found to belong to the typical variety.

Lam (1919) recorded its leaf-base as "acute", but in all the specimens examined the lamina is found to be almost always rounded or truncate but never acute at the base.

A specimen from Taiwan in the National Herbarium of Victoria (MEL 97774), identified as "*C. pilosissima* Maxim.", is found to have several characters in common with *C. caudata* Maxim. It has a similar indumentum on the stem, leaves and inflorescence; leaves about the same general shape with obtuse, rounded or truncate base and long tapering apex; peduncles longer than the petioles; corolla glabrous and ovary glabrous but glandular. If this specimen was correctly identified as *C. pilosissima* then this species should be regarded synonymous with *C. caudata*. Both these species were simultaneously described by Maximowicz (1887), one from the Philippines and the other from Formosa (Taiwan). The above opinion is based only on the available literature, as the present author has not been able to examine a sufficient range of material or their types which are likely to be preserved in the herbarium in Leningrad (LE) (Stafleu, 1976).

The septate hairs on peduncles, pedicels and outside the calyx are generally gland-tipped. In most cases, however, the glands fall off, probably during early stages and the hairs appear glutinous but without a distinct glandular tip.

Affinities

Of the Australian *Callicarpa* species, *C. caudata* is nearest to *C. pedunculata*. Both species have their leaves (lamina) rounded or truncate at the base, ferruginous-tomentose underneath; peduncle longer than the petiole; corolla violet, glabrous all over; ovary glabrous and glandular. However, *C. caudata* may easily be distinguished by its indumentum on stem, petioles and peduncles being mostly of simple septate hairs; leaves with long caudate apex and fruit pink. The hairs in *C. pedunculata* are stellate-dendriform, leaves tapering towards the apex but not caudate and fruit violet-purple. Outside Australia, *C. caudata* seems very close to *C. pilosissima* (see "Comments" above).

Merrill (1910) states that *C. caudata* is closely allied to *C. stenophylla* Merr., which differs "in its less dense and simply stellate, not plumose-stellate indumentum".

7. **Callicarpa pedunculata** R. Br., Prod. Fl. Nov. Holl. (1810) 513; Roem. & Schult., Syst. Veg. 3 (1818) 98; Roem. & Schult., Linn. Mant. Syst. Veg. 3 (1827) 55; Walp., Rep. Bot. Syst. 4 (1845) 127, pro syn. sub *C. lanata* Vahl; Schau. in DC., Prod. 11 (1847) 644, pro syn. sub *C. lanata* Vahl; Benth., Fl. Aust. 5 (1870) 57; F. Muell., Syst. Cens. Aust. Pl. 1 (1882) 103; Bail., Synop. Qld Fl. (1883) 377; Bail., Proc. Roy. Soc. Qld 1 (1884) 70; C.B. Clarke in Hook. f. (ed.), Fl. Br. Ind. 4 (1885) 569; F. Muell., Sec. Syst. Cens. Aust. Pl. 1 (1889) 173; K. Schum. & Hollr., Fl. Kais. Wilh. Land (1889) 119; Bail., Cat. Pl. Qld (1890) 35; Warb., Bot. Jahrb. 13 (1891) 426; Moore, Handb. Fl. N.S.W. (1893) 356; Bail., Qld Fl. 4 (1901) 1174; K. Schum. & Lauterb., Fl. D. Südsee (1901) 522; Britten, Ill. Aust. Pl. Banks & Soland. 2 (1901) 74, t. 237; Bail. in Meston (ed.), Exp. Bell.-Kerr, Parl. Rep. (1904) 14; King & Gamble, Mat. Fl. Mal. Penin. no. 21 (1909) 522; Bail., Comp. Cat. Qld Pl (1913) 382; Maiden & Betche, Cens. N.S.W. Pl. (1916) 178; H.J. Lam., Verbenac. Mal. Arch. (1919) 55 exclud. syn. *C. lanata* Vahl; White, Proc. Roy. Soc. Qld 34 (1923) 50; Domin, Bibl. Bot. 89 (1929) 554; Mold., Fedde Repert. Sp. Nov. Reg. Veg. 40 (1936) 100; Dukkus, Pl. Cult. Hort. Bot. Bog. (1957) 42; Mold., Résumé Verbenac. etc. (1959) 208, 211, 242, 244-48, excld. syn. *C. lanata* Vahl; Phytologia 21 (1971) 387; Fifth Summary Verbenac. etc. 1 & 2 (1971) 344, 349, 350, 407, 412, 415, 418-20, exclud. syn. *C. lanata* Vahl; Everist, Poison. Pl. Aust. (1974) 519; Jacobs & Pickard, Pl. N.S.W., Cens. Cycad. Conif. & Angiosp. (1981) 209.

Lectotype: *R. Brown s.n.*, J.J. Bennett no. 2331, Coast of Northern Queensland, Australia, 1802-5 (BM, lectotype designated here!; E, K, MEL 97636, MEL 97637, NSW 145032—isolectotypes!).

C. cuspidata Roxb., Hort. Beng. (1814) 83 & Fl. Ind. 1 (1820) 409; Spreng., Syst. Veg. 1 (1825) 420; Roem. & Schult., Linn. Mant. Syst. Veg. 3 (1827) 54; Hassk., Cat. Pl. Hort. Bot. Bog. (1844) 136; Walp., Rep. Bot. Syst. 4 (1845) 128.

Type: *E.B. Heyne s.n.*, eastern India, "a native of Moluccas", undated,—probably in Herb. K (n.v.).

C. dentata Roth in Roem., & Schult, Syst. Veg. 3 (1818) 98; Roth, Nov. Pl. Sp. (1821) 81; Blume, Bijdr. Fl. Ned. Ind. (1825) 818; Wall., Cat. (1832) no. 6319; Hassk., Cat. Pl. Hort. Bot. Bog. (1844) 136.

Type: *Heyne s.n.*, eastern India (n.v.).

C. lanata auct. non L. nec. Vahl: Walp., Rep. Bot. Syst. 4 (1845) 127; Schau. in DC., Prod. 11 (1847) 644; Miq., Fl. Ind. Bat. 2 (1858) 886; F. Muell. in Laurie (ed.), Landsb. Explor. Aust. (1866) 119, quoad syn. *C. pedunculata* R. Br.

C. pedunculata R. Br. var. *typica* H.J. Lam, Verbenac. Malay. Arch. (1919) 56; Mold., Résumé Verbenac etc. (1959) 246, pro syn.; Fifth Summary Verbenac. etc. 1 (1971) 415, pro syn.

Type: *Karsten 3059*, Amboyna,—(n.v.). *Forsten s.n.*, Amboyna, 11.v.1842 (n.v.). *Lauterbach 2449*, River A, Camp 2, New Guinea, 3 vii.1896 (n.v.).

C. pedunculata R. Br. var. *glandulosa* H.J. Lam, Verbenac. Malay. Arch. (1919) 57; Mold., Résumé Verbenac. etc. (1959) 246, pro syn.; Fifth Summary Verbenac. etc. 1 (1971) 321, 335.

Type: *Forsten s.n.*, Tondano, Celebes, May, 1840 (n.v.). *Hollrung 210*, Sattel Mountain, New Guinea, July, 1886 (n.v.).

C. pedunculata R. Br. var. *glabriuscula* H.J. Lam, Verbenac. Malay. Arch. (1919) 57; Mold., Résumé Verbenac. etc. (1959) 246, pro syn.; Fifth Summary Verbenac. etc. 1 (1971) 321, 329, 331, 356, 414.

Type: *Blume s.n.*, Java,—(n.v.). *Hallier 121*, Key Islands,—(n.v.). *Elbert 4503*, Mongowe, near Saiwerang, Wetar, 19.ii.1910 (L!).

C. pedunculata R. Br. var. *psilocalyx* H.J. Lam, Verbenac. Malay. Arch. (1919) 57; Mold., Résumé Verbenac. etc. (1959) 246, pro syn.; Fifth Summary Verbenac. etc. 1 (1971) 335.

Type: *Nyman 580*, Saedel-Mountain, New Guinea, July, 1899 (n.v.); *Schultze 194*, Augusta River, New Guinea, Jan. 1913 (n.v.); *Schlechter 16731*, Hami Mountains, New Guinea, 27.x.1907 (n.v.).

C. viridis Domin, Bibl. Bot. 89 (1929) 554, fig. 179 p.p.; Mold., Résumé Verbenac. etc. (1959) 208; Fifth Summary Verbenac. etc. 1 (1971) 344, *syn. nov.*

Type: *Domin 8117 & 8118*, Harveys Creek, N. Queensland, Australia, Jan. 1910 (PR!).

Typification

C. pedunculata is based on R. Brown's collection (s.n.) from the east coast, Queensland, consisting of at least 6 duplicates, all of which remained in Robert Brown's possession until after his death. On his death, his herbarium went to the British Museum where the main set is still held. A complete and well preserved syntype of this species in Herb. BM, annotated by Robert Brown, and almost certainly used by him in preparing the original diagnosis of this species, is selected here as the lectotype. The lectotype and its duplicates bear J.J. Bennett's no. 2331.

Description (Fig. 7)

A shrub or small tree (2-) 3-4 (-6) m tall. *Stem* and branches densely clothed with yellowish-brown or ferruginous tomentum of stellate-dendriform hairs. *Leaves*: lamina ovate, ovate-lanceolate or oblong-ovate, with rounded, truncate or somewhat subcordate base, tapering towards the apex, serrate-dentate along the margins, (5-) 6-18 cm long, 3-6 (-8) cm wide across the middle, membranous, sparsely pubescent above with simple hairs, glandular and densely brownish-tomentose beneath with stellate-dendriform hairs; petiole densely dendriform-tomentose, 0.5-0.8 (-1.5) cm long. *Infloresence* rather lax, sometimes inserted a little above the leaf-axil; primary peduncles slender, longer than the petiole, 0.8-1.8 (-2.7) cm long, densely tomentose. *Flowers* subsessile or

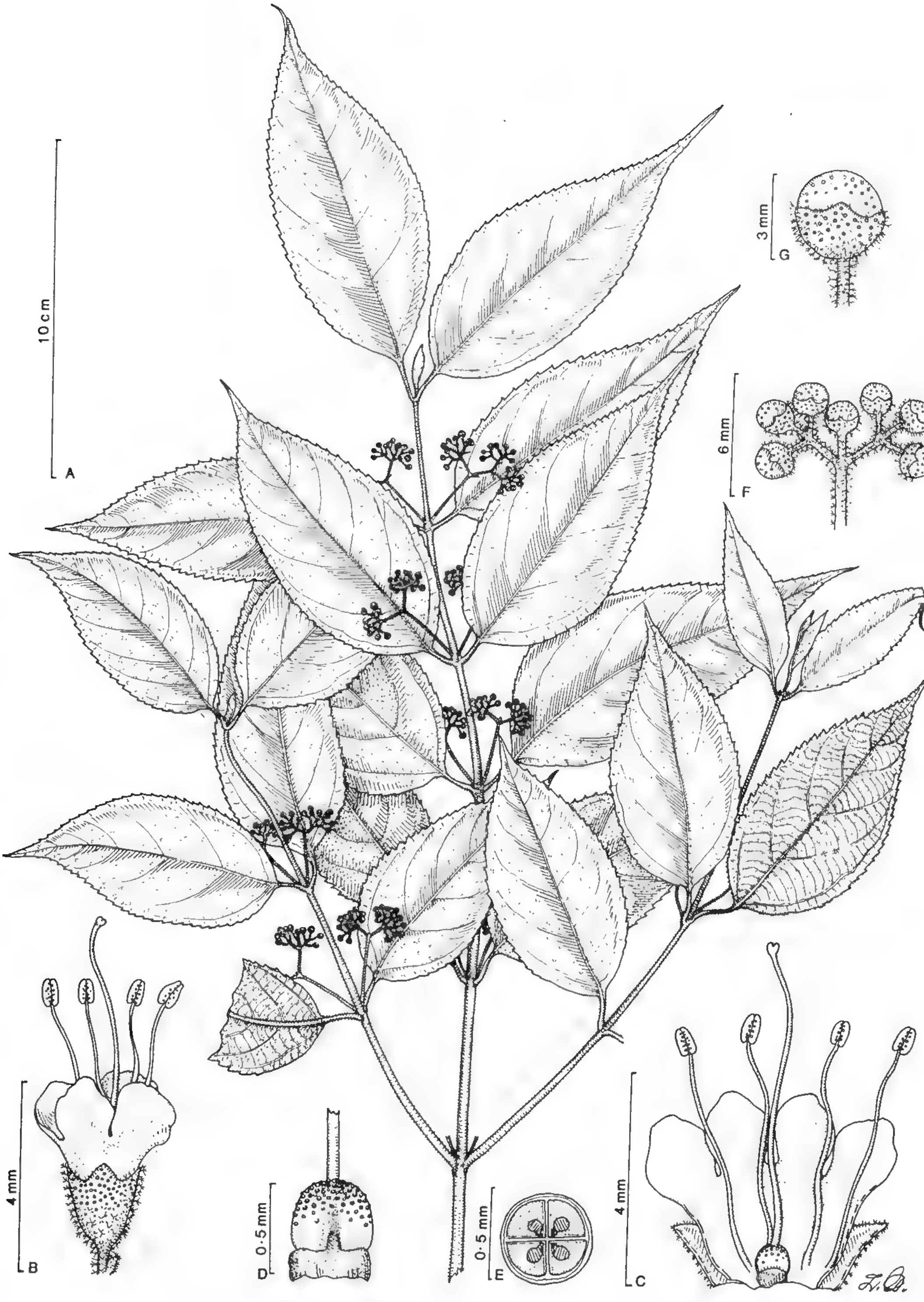


Fig. 7. *Callicarpa pedunculata* R. Br. (A, *W.J.F. McDonald 3218*: BRI; B-G, *C. Fawcett s.n.*: MEL 97651). A, fruiting branch; B, flower; C, flower vertically cut open to show androecium and gynoecium; D, ovary; E, transverse section of ovary; F, infructescence; G, fruit with pesistent calyx.

shortly pedicellate pedicels 0.5-1 mm long. *Calyx* cup-shaped, minutely 4-toothed, densely glandular and stellate-dendriform hairy outside, glabrous within, 1-1.5 mm long, ± 1 mm across top. *Corolla* purple or mauve, glabrous all over, (2-) 2.5-3 mm long; lobes almost orbicular in outline, ± 1 mm long, nearly as broad; tube ± cylindrical, slightly dilated towards the apex, 1.5-2 mm long, almost as broad at the top. *Stamens* exserted, inserted near the base of the corolla-tube; filaments equal, 4-6 mm long; anthers oblong, glandular along the connective, ± 1 mm long, ± 0.5 mm broad. *Ovary* globular, glabrous, glandular but more so at the top, 0.5-1 mm in diameter; style exserted, glabrous, 5-8 mm long, stigma capitate, slightly 2-fid. *Fruit* globular, almost succulent, glabrous, glandular chiefly at the top, whitish-mauve or violet-purple when ripe and fresh, 2-3.5 (-4) mm in diameter.

Representative specimens (collections seen: Australian 137, non-Australian 14)

AUSTRALIA: NEW SOUTH WALES: *Betche 176*, Lismore, March, 1891 (MEL); *Boorman s.n.*, Coff's Harbour, May, 1909 (NSW 145043); *Coveny 10551 & Hind*, Toonumbar State Forest, 25.xii.1979 (BRI, NSW); *Fawcett s.n.*, Richmond River,—(MEL 97650, MEL 97651, MEL 97654); *Floyd 828*, Long Gully near Drake, 17.i.1978 (NSW); *Forsyth s.n.*, Byron Bay, Oct., 1898 (MEL 97639); *Maiden & Boorman s.n.*, Brunswick River, Dec. 1903 (NSW 145037); *McLean 54*, Casino, April, 1918 (BRI, NSW); *Rupp s.n.*, Camel Back Mt, Upper Clarence River, July, 1910 (MEL 97697); *Tomlins s.n.*, Alstonville, "before 1917" (NSW 145041); *Vickery 23857*, Toolom Range, 17.iv.1953) (L, NSW); *Ward L2*, Lowanna, April, 1943 (SYD).

QUEENSLAND: *Bailey s.n.*, Brisbane River, March, 1875 (BRI 261542); *R. Brown s.n.*, East Coast, Queensland, 1802-5 (BM, lectotype!, E, K, MEL 97636-7, NSW 145032—isolectotypes!); *Cunningham 82*, Endeavour River, 1819 (MEL); *Dallachy s.n.*, Rockingham Bay, 13.xi.1864 (MEL 97648); *Dietrich 409*, Rockhampton, Aug., 1865 (MEL 97716-7, PR); *Dietrich 2525*, Port Mackay,—(MEL 97710, PR); *Domin 8106*, Yarraba, Jan., 1910 (PR); *Domin 8107 & 8108*, Mt Tambourine, Jan., 1910 (PR); *F. Muell s.n.*, Dawson River,—(MEL 97642); *Persieh 197 & 278*, Endeavour River, 1885 (MEL—2 spec.); *Sayer 110*, Russell River, 1886 (MEL 97739); *Webb & Tracy 5617*, end of Davies Creek, 23.i.1962 (BRI, CANB); *White 1957*, Mt Glorious, 6.v.1923 (NSW).

NEW GUINEA: *Conn 116*, Baiune River, Bulolo, 13.iii.1977 (LAE, A, BFC, CANB, K, L); *Henty & Streimann NGF 38861*, Baiyer River, Mt Hagen subdistr., 29.viii.1968 (BRI, A, CANB, K, L, BO); *Hoogland 4246*, 1 km E. of Guruguru, Tufi subdistr., 2.vii.1954 (BRI, CANB, A, BM, L, LAE); *Schlencker s.n.*, Boku, Papua,—(BRI 261335); *Streimann & Kairo NGF 39117*, upper Baiune, Wau subdistr., 8.x.1968 (BRI, CANB, LAE, L); *Womersley & Floyd 6806*, Baiyer River, 26.xi.1954 (BRI, CANB, L).

INDONESIA: *Elbert 4503*, Mongowe near Saiwerang, Wetar, Moluccas, 19.ii.1910 (L—2 spec., syntype of *C. pedunculata* R. Br. var. *glabriuscula* H.J. Lam). *Forsten s.n.*, Ambon, Moluccas, 14.iv.1842 (L—2 spec.).

TIMOR: *Forbes 3601*, Kupang, April-May, 1882 (L).

VIETNAM: *d'Alleizette s.n.*, Quang Yen, Tonkin, Dec. 1908 (L).

Distribution (Map 3)

In Australia *C. pedunculata* has been found only in New South Wales and Queensland. The localities in New South Wales are in the far north-eastern part of the state where it mostly occurs in the area known as the "MacPherson—Macleay Overlap". In Queensland, the distribution is chiefly in the tropical region of the east-coast mainly in the area between Cooktown and eastern-most part of the northern border of New South Wales. So far, only a few inland collections have come to hand.

Collections from outside Australia have been examined from New Guinea, Timor, the Moluccas and Vietnam. Lam (1919) recorded this species from most parts of "Malesia" and tropical Australia, but Moldenke (1971) has noted several additional localities, namely Sikkim, Eastern India, Upper Burma, Southern China, Hong Kong, Taiwan, the Solomon Islands and New Zealand. He has also noted its occurrence on Lizard Island in the Great Barrier Reef, which has not been confirmed by any *Callicarpa* collection in Herb. BRI or other Australian herbaria. The New Zealand record may have come from cultivation because this genus is not known to occur wild in any part of that country. According to Moldenke (1971), *C. pedunculata* has been cultivated in France, the Hawaiian Islands, India and Java.

Comments

Lam (1919) distinguished four new varieties under this species, namely var. *typica*, var. *glandulosa*, var. *glabriuscula* and var. *psilocalyx*, differing chiefly on the shape of their leaves and density of indumentum on leaves and calyces. Moldenke (1959) regarded all these varieties as identical with the typical variety and thus recorded them all as synonyms of the typical form. Subsequently, however, Moldenke (1971) re-instated the vars *glandulosa*, *glabriuscula* and *psilocalyx* to their original status. During the present investigations, the characters on which Lam (1919) separated these varieties were found to be unstable. The leaf-shape and their size is found to be variable within specimens of the same collection. It also depends whether a collection came from a young or fully grown fruiting plant. The same is true with the indumentum on the leaves and calyces. Fully developed leaves are generally almost glabrescent on the adaxial surface, as are the mature calyces on the outside. These characters overlap so much within these varieties that it is not possible to draw a definite line of demarcation between these taxa. In view of this, following Moldenke (1959) all Lam's new varieties are regarded here as synonymous with the typical var. *pedunculata*.

Vahl (1794) described a collection in Herb. Herman as *Callicarpa lanata* and cited with it *Tomex tomentosa* L. (1748) and *C. lanata* L. (1771) showing that he was recording only Linnaeus' previously described species. The species name published by Vahl (1794), however, was erroneously taken by Walpers (1845), Schauer (1847) and Miquel (1858) as new. In their publications, it is recorded as "*C. lanata* Vahl" with *C. pedunculata* R. Br. (1810) as a synonym. The name "*C. lanata* Vahl", even if intended to be new, is a later homonym of *C. lanata* L. (1771), and would, therefore, be illegitimate. The former was placed in synonymy under *C. pedunculata* R. Br. by Lam (1919) and Moldenke (1959, 1971), although Vahl (1794) indicated clearly that the name *C. lanata* is that of Linnaeus, which applies to a species distinct from *C. pedunculata* R. Br. If, however, there is any element in Vahl's description that belongs to *C. pedunculata* R. Br. that element should be treated in the category of taxonomic misapplication of the name. I have not seen the specimen(s) on which Vahl based his description. In the present treatment, however, *C. lanata* sensu Vahl is not regarded as a synonym under *C. pedunculata* R. Br.

According to Lam (1919), the plant indumentum is of "stellate hairs" and "corolla sparsely and softly hairy or almost glabrous". During present investigations, the indumentum on stem, leaves and inflorescence was found to be mainly of dendriform hairs and the corolla always glabrous. Of all the Australian *Callicarpa* species, a softly hairy corolla is found only in *C. longifolia* Lam. A few hairs are also present on the outside of the corolla-lobes of *C. thozetii*, but no hairs were found on the corolla of any collection of *C. pedunculata* R. Br. excepting *Jones 3951* (CANB).

In the following collections from New South Wales, the stamens, style and stigma are found to have hairs of various density: *Boorman s.n.* (NSW 145043); *Coveny & Hind 10571* (BRI); *Floyd 828* (NSW); *Jones 3951* (CANB); *Maiden & Boorman s.n.*, (NSW 145037). The presence of hairs on the sexual parts of these specimens seems an abnormal character because other collections from the same area have no hairs on their stamens and style. As mentioned above, the corolla in *Jones 3951* (CANB) is also somewhat hairy on the outside. In all other characters, these specimens agree closely with *C. pedunculata*.

Affinities

C. pedunculata is closely related to *C. thozetii* in its primary peduncles being longer than the petioles; lamina ferruginous-tomentose beneath; stem and inflorescence indumentum of stellate-dendriform hairs; corolla blue or violet; ovary glabrous, glandular;

fruit deep purple when ripe. However, *C. pedunculata* may easily be distinguished by its lamina being rounded or subcordate at the base; corolla glabrous all over and stamens and style much more exserted.

C. pedunculata is also very near to *C. caudata* in its lamina being rounded or subcordate at the base, ferruginous-tomentose beneath; primary peduncles longer than the petioles; corolla violet-mauve, glabrous; ovary glabrous, glandular, and fruit violet-purple when ripe. Nevertheless, *C. pedunculata* may easily be distinguished by its indumentum on stem and inflorescence being stellate-dendriform hairs; leaves ovate with a short tapering apex. In *C. caudata*, the hairs on stem and inflorescence are mainly simple, septate and leaves narrowly lanceolate with long tapering apex.

There is also a close resemblance between *C. pedunculata* and *C. macrophylla* in their lamina being rounded at the base; peduncles longer than the petioles; corolla violet-mauve, glabrous; indumentum on stem and inflorescence of stellate-dendriform hairs and ovary glabrous and glandular. The latter, however, may be readily identified by its lamina being greyish-white tomentose beneath, and fruit white when mature.

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References

Adanson, M. (1763). Jasmina. "Familles des Plantes". Vol. 2: 220-226. (Vincent: Paris).

Backer, C.A. & Bakhuizen van den Brink, R.C. (1965). Verbenaceae. "Flora of Java". Vol. 2: 594-614. (P. Noordhoff: Groningen).

Bailey, F.M. (1883). Verbenaceae. "A Synopsis of the Queensland Flora": 375-381. (Government Printer: Brisbane).

Bailey, F.M. (1890). Verbenaceae. "Catalogue of the indigenous and naturalized Plants of Queensland: 35. (Government Printer: Brisbane).

Bailey, F.M. (1901). Verbenaceae. "The Queensland Flora". Part IV: 1164-1185. (H.J. Diddams & Co.: Brisbane).

Bailey, F.M. (1913). Verbenaceae. "Comprehensive Catalogue of Queensland Plants". 381-387. (Government Printer: Brisbane).

Bentham, G. (1870). Verbenaceae. "Flora Australiensis". Vol. V: 31-70. (L. Reeve & Co.: London).

Bentham, G. & Hooker, J.D. (1876). Verbenaceae. "Genera Plantarum". Vol. 2: 1131-1160. (L. Reeve & Co.: London).

Bojer, W. (1837). Verbenaceae. "Hortus Mauritianus": 254-259. (A. Mamarot & Co.: Mauritius).

Briquet, J. (1895). Verbenaceae. In Engler, A. & Prantl, K., "Die natürlichen Pflanzenfamilien". IV, 3a: 132-182. (Wilhelm Engelmann: Leipzig).

Brown, R. (1810). Verbenaceae. "Prodromus Florae Novae Hollandiae et Insulae Van-Diemen": 510-514. (Richard Taylor & Co.: London).

Burkill, I.H. (1966). "A Dictionary of the economic Products of the Malay Peninsula". Vol. 1. Reprinted edition. (Malaysian Ministry of Agriculture: Kuala Lumpur).

Clarke, C.B. (1885). Verbenaceae. In Hooker, J.D., "The Flora of British India". Vol. IV: 560-604. (L. Reeve & Co.: London).

Dalla Torre, C.G. & Harms, H. (1904). Verbenaceae. "Genera Siphonogamarum ad Systema Englerianum Conscripta": 429-434. (Wilhelm Engelmann: Leipzig).

Domin, K. (1929). Beiträge zur Flora und Pflanzengeographie Australiens. *Bibl. Bot.* Heft 89 (vi): 551-562.

Durand, Th. (1888). Verbenaceae. "Index Generum Phanerogamorum": 319-322. (Dulau & Co.: London).

Endlicher, S.L. (1836). Verbenaceae. "Genera Plantarum Secundum Ordines Naturales Disposita". Vol. 1: 632-639. (Fr. Beck: Vienna).

Endlicher, S.L. (1841). Verbenaceae. "Enchiridion Botanicum": 311-314. (Wilhelm Engelmann: Leipzig).
Everist, S.L. (1974): "Poisonous Plants of Australia". (Angus & Robertson: Sydney).
Ewart, J. & Davies, O.B. (1917). Verbenaceae. "The Flora of the Northern Territory": 235-239. (McCarron, Bird & Co.: Melbourne).
Forbes, F.B. & Hemsley, W.B. (1890). An Enumeration of all the Plants known from China Proper, Formosa, Hainan, Corea, the Luchu Archipelago, and the Island of the Hong Kong, together with their distribution and synonymy. *J. Linn. Soc. (Bot.) 26*: 251-266.
Gaertner, J. (1791). "De Fructibus et Seminibus Plantarum". Vol. 2. 80-81. (G.H. Schramm: Tubingen).
Gardner, C. (1931). Verbenaceae. "Enumeratio Plantarum Australiae Occidentalis". Part III: 111-113. (Government Printer: Perth).
Hooker, J.D. (1859). "The Botany of The Antarctic Voyage". Part III. Flora Tasmaniae. Vol. 1: XLVI. (L. Reeve: London).
Junell, S. (1934). Zur Gynäceummorphologie und Systematik der Verbenaceen und Labiaten. *Symb. Bot. Upsal.* 4: 1-219.
Jussieu, A.L. (1789). Vitices. "Genera Plantarum Secundum Ordines Naturales Disposita": 106-110. (Viduam Herissant & T. Barrois: Paris).
King, G. & Gamble, J.S. (1909): Verbenaceae. "Material for a Flora of The Malayan Peninsula". Vol. 4: 1004-1079. (W. Newman & Co.: London).
Lam, H.J. (1919). "The Verbenaceae of the Malayan Archipelago". (M. De Waal: Groningen).
Lamarck, J.B.A.P. de (1783). "Encyclopedie Methodique Botanique". Vol. 1. (Plomteux: Liege).
Lamarck, J.B.A.P. de (1791). "Tableau Encyclopedique et Methodique des Trois Regnes de la Nature. Botanique". Vol. 1. (Pancoucke: Paris).
Lemée, A, (1843). Verbenaceae. "Dictionnaire descriptif et Synonymique des Generes de Plantes phanerogames". Vol. 8b: 650-657. (Imprimerie Commerciale et Administrative: Brest).
Linnaeus, C. (1747). "Flora Zeylanica". (J. Wetstenium: Amsterdam).
Linnaeus, C. (1753). "Species Plantarum". ed. 1, Vol. 1. (Laurentius Salvius: Stockholm).
Linnaeus, C. (1771). "Mantissa Plantarum Altera Generum editionis VI & Specierum editionis II". (Laurentius Salvius: Stockholm).
Lopez-Palacios, S. (1977). Verbenaceae. "Flora De Venezuela". (University de Los Andes: Merida).
Loureiro, J. (1793). "Flora Cochinchinensis". edn 2. Vol. 1. (Haude & Spener: Berlin).
Maximowicz, C.J. (1887). Verbenaceae orientaliasiaticae. *Bull. Acad. Imp. Sc., St. Petersb.* Vol. 31: 73-105.
Meisner, C.F. (1840). Verbenaceae. "Plantarium Vascularium Genera Secundum Ordines Naturales Digesta ......". Vol. 1. "Tabulis Diagnosticis": 290-292. Vol. 2. "Commentarius": 197-200. (Libraria Weidmannia: Leipzig).
Merrill, E.D. (1923). Verbenaceae. "An Enumeration of Philippine Flowering Plants". Vol. 3: 38-408. (Bureau of Science: Manila).
Miquel, F.A.W. (1858). Verbenaceae. "Flora Indiae Batavae". Vol. 2: 856-913. (C.G. van der Post: Amsterdam).
Moldenke, H.N. (1936). A monograph of the genus *Callicarpa* as it occurs in America and in cultivation. *Fedde Repert. Sp. Nov. Reg. Veg.* Vol. 39: 288-317. Vol. 40: 38-131.
Moldenke, H.N. (1959). "A Résumé of the Verbenaceae, Avicenniaceae, Stilbaceae, Symphoremaceae, and Eriocaulaceae of the World as to valid taxa, geographic distribution and synonymy". (H.N. Moldenke: Mountainside, New Jersey).
Moldenke, H.N. (1971). "A Fifth Summary of the Verbenaceae, Avicenniaceae, Stilbaceae, Dicrastylidaceae, Symphoremaceae, Nyctanthaceae, and Eriocaulaceae of the World as to valid taxa, geographic distribution, and synonymy". Vol. 1 & 2. (H.N. Moldenke: Wayne, New Jersey).
Moldenke, H.N. (1971). Additional materials toward a monograph of the genus *Callicarpa*. XV. *Phytologia* 21: 208-242.
Mueller, F.v. (1882). Verbenaceae. "Systematic Census of Australian Plants". Part 1. Vasculares: 102-103. (McCarron, Bird & Co.: Melbourne).
Mueller, F.v. (1889). Verbenaceae. "Second Systematic Census of Australian Plants". Part 1. Vasculares: 171-173. (McCarron, Bird & Co.: Melbourne).
Murray, J.A. (1774). "Caroli a Linné ...... Systema Vegetabilium Secundum Classes, Ordines, Genera, Species cum Characteribus et Differentiis". (J.C. Dietrich: Göttingen).
Necker, N.J. (1790). "Elementa Botanica Genera Genuina, Species Naturales Omnium Vegetabilium ......". (Societatas Typographica: Neowedae ad Rhenum).
Prain, D. (1963). Verbenaceae. "Bengal Plants". Reprint edition. Vol. 2: 614-626. (Botanical Survey of India: Calcutta).
Raeuschel, E.A. (1797). "Nomenclator Botanicus". Edition 3. (J.G. Feind: Leipzig).
Reichenbach, H.G.L. (1828). Labiatae. "Conspectus Regni Vegetabilis Per Gradus Naturales Evoluti". Part 1: 115-117. (Carolus Cnobloch: Leipzig).
Ridley, H.N. (1923). Verbenaceae. "The Flora of the Malay Peninsula". Vol. 2: 611-642. (L. Reeve & Co.: London).
Roemer, J.J. & Schultes, J.A. (1818). "Caroli a Linné ...... Systema Vegetabilium. Secundum. Classes. Ordenes Genera Species ...... ". Vol. 3: (J.G. Cotta: Stuttgart).

Roemer, J.J. & Schultes, J.A. (1827). "Mantissa in Volumen Tertium Systematis Vegetabilium Caroli a Linné ex Editionis". Vol. 3. (J.G. Cotta: Stuttgart).
Roth, A.W. (1821). "Novae Plantarum Species Praesertim Indiae Orientalis ex Collectione Dr Benjamin Heynii . . . . . .". (Vogler: Habberstadt).
Roxburgh, W. (1814). Tetrandria Monogynia. "Hortus Bengalensis, or A Catalogue of the Plants growing in The Honourable East India Company's Botanic Garden at Calcutta". 83. (C.H. Pearson: Calcutta).
Roxburgh, W. (1820). Tetrandria Monogynia. "Flora Indica or Descriptions of Indian Plants. Edited by William Carey, to which are added descriptions of Plants more recently discovered by N. Wallich. Vol. 1: 405-411. (Missions Press: Serampore, Calcutta).
Rüling, J.P. (1774). Sambuci. "Ordines Naturales Plantarum Commentatio Botanica". 61. (A. Vandenhoeck: Göttingen).
Schauer, J.C. (1847). Verbenaceae. In de Candolle, A., "Prodromus Systematis Naturalis Regni Vegetabilis". Vol. XI: 522-700. (Victoris Masson: Paris).
Spreng, K. (1825). Tetrandria Monogynia. "Caroli Linnae I, ... Systema Vegetabilium Editio Decima, Sexta". Vol. 1: 419-421. (Dietrich: Göttingen).
Stafleu, A. (1967). "Taxonomic Literature". (International Bureau for Plant Taxonomy and Nomenclature: Utrecht).
Vahl, M. (1794). *Callicarpa*. "Symbolae Botanicae sive Plantarum Tam earum, ... ". Part 3: 12-14. (Nicolaus Möller et Filius: Hauniae).
Walpers, W.G. (1845). Verbenaceae. "Repertorium Botanices Systematicae". Vol. 4: 3-314. (Fr. Hofmeister: Leipzig).

Index to Collections

Collector names are in alphabetical order, and their numbers (in Arabic numerals) are followed by the number (in Roman numerals) given below to each species. T indicates (holo-, lecto- or syn-) types of the species indicated.

Callicarpa thozetii	= I	*C. macrophylla*	= V
C. longifolia	= II	*C. caudata*	= VI
C. brevistyla	= III	*C. pedunculata*	= VII
C. candicans	= IV		

d'Alleizette s.n./VII.—*Andrews & Simon* 181/II; s.n., MEL 97782/II.—*Armit* 477, 1029-1039, s.n., MEL 97618/IV.—*Backer* 7942, 36653/IV.—*Bailey* s.n., BRI 261542, BRI 261550, s.n., NSW 145054/VII.—*Bancroft* s.n., BRI 261552/VI; s.n., BRI 263193/VII.—*Banks & Solander* s.n., MEL 97657-58/VII.—*Barker* LAE 67711/VI.—*Barnard* s.n., MEL 97728/VII.—*Beccari* 491/II.—*Beckler* s.n., MEL 97666/VII.—*Beguin* 1229/VI.—*Betche* s.n., NSW 145034, 176/VII.—*Berthoud* s.n., MEL 97700/VI.—*Bich* s.n./IV.—*Blake* 12731/I; 8228, 13549/IV.—*Boorman* s.n., NSW 145043, NSW 145050-51/VII.—*Bowman* s.n., MEL 97630/II; s.n., MEL 97611/IV; s.n., MEL 97630/VII.—*Bradtke* 232, 376/IV; 298/V.—*Brass* 1013, 1415, 7958, 29348/II; 280/IV: 5520, 11776, 31562/VI; 2356/VII.—*F. Brown* s.n., NSW 145038/VII.—*R. Brown & J.J. Bennett* No. 2331/VIIT; MEL 97636-37, s.n., NSW 145032/VIIT.—*Burkill* 245/II.—*Buwalda* 4316, 5103/II.—*Byrnes* 1309/IIIT: 3201, 1235/IV.—*Byrnes & Clarkson* 3599/VII.—*Cameron* 20137, 20220-21, 20239/IV.—*Carr* 1198, 16137, 16297, 16385/II; 13163/VI.—*Chew, Corner & Stainton* s.n./II.—*Christensen* W142/VI.—*Clarke* ANU 9508/VI.—*Cleland* s.n./VII.—*Conn* 116/VII.—*Coode, Cropley & Katik* NGF 2976/II.—*Coode & Katik* NGF 32782/II; NGF 40110/IV.—*Coveny & Hind* C10551, C10571/VII.—*Cowley* s.n., NSW 145055/II; 25/IV.—*Craven* 3556/IV.—*Craven & Schodde* 1414/II.—*Cuadra* A1007, A2248, A2265/II.—*Cuming* 1283/IV; 1095/VIT.—*Cunningham* 82/VII.—*Daintree* s.n., MEL 97602/IV.—*Dallachy* 54, s.n., MEL 97644/I; s.n., MEL 97620-29, s.n., MEL 97631-35/II; s.n., MEL 99614-15/IV; s.n., MEL 97648, MEL 97683/VII; 54 p.p., 255/VII.—*Darbyshire* 922/II.—*Darbyshire & Hoogland* 8003/II.—*Dietrich* 726/I; 2458, 2498/II; 409, 1341, 1342, 1453, 1762, 2525, 2534, 2510/VII.—*Djamhari* 432/II.—*Dockrill* 1452/II.—*Domin* 8120-21/II; 3430, 8103, 8104, 8105/IV; 8106-08/VII; 8117-18/VIIT.—*Dunlop* 3115, 4660/IV.—*Easton* 1008/IV.—*Eaves* s.n., MEL 97743/V; s.n., MEL 97734, MEL 97676-77, MEL 97688, MEL 97691-93/VII.—*Edano* s.n./IV.—*Elbert* 3534/IV: 4503/VIIT.—*Elmer* 20102/II.—*Falconer* 748/V.—*Fallen, Howcroft & Jurua* 510/VI.—*Fawcett* s.n., MEL 97650, MEL 97651, MEL 97654/VII.—*Field Nat. Soc.* s.n., BRI 261548/VII.—*Fielding* 13062/II.—*Fitzalen* s.n., MEL 97607, MEL 97608/IV; s.n., MEL 97661, MEL 97666, MEL 97695, MEL 97689, MEL 97690, MEL 97694/VII.—*Fitzgerald* 616, s.n./IV.—*Flecker* 1660, 3301, 5549, 9195, 13063/II: s.n./IV; 5398, 9272/VII.—*Floyd* 7288/II; 828/VII.—*Forbes* 783/II; 3601/VII.—*Forman & Kumul* NGF 48250/II.—*Forman & Vinas* LAE 60285/II.—*Forsten* s.n./VII.—*Forsyth* s.n., MEL 97639/VII.—*Frake* PNH 36163/IV.—*Francis* s.n., BRI 260719/II.—*Francis & White* s.n., BRI 261539, NSW 145048/VII.—*Froggat* 40, s.n., MEL 97605/IV.—*Fryer* 3984/II.—*Gribble* s.n., MEL 560524, MEL 560605/VII.—*Gulliver* 51/VII.—*Hai Ngan & Lei* 155/IV.—*Hallier* 269/IV.—*Hardial* 530/II.—*Hartley* 11365/II; 11462, 12051, 13039/VI.—*Havel & Kairo* NGF 7598/II.—*Heatwole & Cameron* 482, 573/IV.—*Henderson* 18202/II; s.n., BRI 223001/IV.—*Henry* 4625/II; 3079/VII.—*Henty* NGF 11694, NGF 11980, NGF 14366/II.—*Henty & Frodin* NGF 27280/IV.—*Henty, Ridsdale & Glore* NGF 31839/II.—Henty & Streimann NGF 28861/VII.—

Hoogland 3653, 5006, 8858/II; 4246/VII.—*Hoogland & Craven* 10072, 10272/II.—*Hoogland & Pullen* 5328/VI.—*Hooker* s.n., MEL 97756/IV.—*Hubbard & Winders* 6650, 6736/IV.—*Hyland* 6075, 6343, 6668, 8979, 9844, 9934/IV.—*Irvine* 122, 204/II; 283/IV: 138, 793/VII.—*Isles & Vines* NGF 33827/II.—*Johns* NGF 47231/II.—*Johnson* s.n., MEL 97745/VII.—*Jones* 3951, 2431/VII.—*Junghuhn* 5/IV.—*Kadir* A925, A574, A658, A2886/II.—*Kajewski* 2420/VI; 9, 1361/VII.—*Kalkman* 4250, BW6304/II.—*Kanis* 1203/VI.—*Karsten* s.n., MEL 97704-5/VII.—*Karster* s.n., MEL 97708/II.—*Kasin* 395/II.—*Katik* LAE 56300/II.—*Kenney* s.n., BRI 260715/II: s.n., BRI 261541/VII.—*Koorders* 9704, 121548, 27104B/II; 21928, 2708B/IV.—*Kooy* 328/IV.—*Kostermans* 6503, 18557/II.—*Kostermans & Wirawan* 302/IV.—*Krukoff* 4035/II.—*Lamont* 1/VII.—*Lawrie* s.n., BRI 118976/II; 8/IV.—*Leichhardt* s.n., NSW 145033/VII.—*Levitt* s.n., DNA 4438, DNA 4444/III.—*Lockyer* 152/VII.—*Macfarlane* s.n., BRI 083083/II.—*Main* 411, 1722/II.—*Maiden & Boorman* s.n., NSW 145044/VII.—*McDonald, Fisher & Ryan* 3218/VII.—*McKee* 6006, 6193/V; 9140/VII.—*McLean* 54/VII.—*Meston Exped.* s.n., NSW 145049/VII.—*Meer* s.n./IV.—*Meijer* 6652/II.—*Mendoza* 1099/VI.—*Merrill* 1727/VI.—*Michael* 876/VII.—*Millar* NGF 12223; NGF 23454, NGF 35325, NGF 37704/II: 9/IV: 17543/VI.—*Millar & Dockrill* NGF 22883/II.—*Millard* KL1863/II.—*Moriarty* 1383/II: 2538/VI.—*F. Mueller* s.n., MEL 97610, MEL 97612, MEL 97613, MEL 97616/IV; s.n., MEL 97644, MEL 97660, MEL 97682, MEL 97699, MEL 97642, MEL 97652, MEL 97653, MEL 97681, MEL 97663-65, MEL 97667-73, 118, 124/VII.—*Muliadi* A841/II.—*Nicolle* s.n., NSW 145036/VII.—*Nilson* s.n., BRI 261338/VII.—*O'Farrell* 114/VII.—*Ooststroom* 13407/II.—*O'Shanesy* 84, 137, 242/VII.—*Paijmans* 1348, 1398/VI.—*Pentzcke* s.n., MEL 97737/VII.—*Persieh* 191, 693, 876, 908, 1017, 1071, s.n./IV; 90, 91, 197, 278/VII.—*Persietz* s.n., MEL 97748, MEL 97726, MEL 97741/IV; 175, 206, s.n., MEL 97749, MEL 97686/VII.—*Pleyte* 667/II.—*Powell* UPNG 1537/VI.—*Pullen* 1866/II; 8048/VI.—*Quezon* s.n., BRI 263334/IV.—*Ramos* 1958/IV.—*Ramsay* s.n., MEL 97674-75, MEL 97696/VII.—*Randall* 17/VII.—*Rickerley* s.n., NSW 145042/VII.—*Rieck* s.n., MEL 97687/VII.—*Ridsdale* NGF 33611/II.—*Risley* 140, 502/VII.—*Robbins* 1999/II; 2892/VI.—*Ruthwell* s.n., NSW 145039/VII.—*Royen* 3004/II.—*Royen & Millar* NGF 17543/VI.—*Royen & Sleumer* 6875/II.—*Rudder & Nicholson* 3646/VII.—*Rupp* s.n., MEL 97697, NSW 145035/VII.—*Sayer* 199, s.n., MEL 97718, MEL 97738/II; s.n., MEL 97703, MEL 97735, MEL 97736, 110/VII.—*Sayers* NGF 13219/II; NGF 21499/VI.—*Schlencher* s.n., BRI 261335/VII.—*Schodde* 2148/II; 1353, 4785/VI.—*Schodde & Craven* 4275, 4792/II.—*Schomburgk* s.n./VII.—*Scrambler* FRI 20773/II.—*Scarth-Johnson* 154A, 745A/II: 734A/VII.—*Shmull* 7/IV.—*Sije* BW5566/II.—*Simmonds* s.n., BRI 114488, BRI 261547/VII.—*Simon* 2637/VII.—*Singh* 81/II.—*Smith* NGF 49/II; 4194, 4195/VII.—*Sonnerat* s.n./IIT.—*Squires* 188/IV.—*Statter* s.n., BRI 261543/VII.—*Stephens* s.n., NSW 145047/VII.—*Stocker* 683/II; 684/VII.—*Streimann & Kairo* NGF 39117/VII.—*Streimann & Lelean* LAE 52588/VII.—*Swain* s.n., NSW 145045/VII.—*Tangulon* A1558/II.—*Tech. Museum Syd.* s.n., NSW 145046/VII.—*Tenison-Wood* 4/VII.—*Teysmann* s.n., MEL 97757-58/IV.—*Thorsborne* 12/VII.—*Thozet* s.n., MEL 97646/IT; 3/1; 188/VII.—*Tomlins* s.n., NSW 145041/VII.—*Turner* 131/VII.—*Veldkamp* 6167/II.—*Versteegh* BW 3056/VI.—*Vessey* s.n., JCTS-4134/IV.—*Vickery* 23857/VII.—*Vink* BW 12038/II: 16438/VI.—*Volck* 1792/VII.—*Walsh* 334/VII.—*Ward* L2/VII.—*Webb* 621/II.—*Webb & Tracy* 5739, 7883/II; 10177/IV; 5617/VII.—*Weld* s.n., MEL 97744/VII.—*Wheeler* ANU 6230/VI.—*Whiffin* 612/II.—*Whiffin & Risley* 585/VII.—*C.T. White* 1405, 1537, 8979, 12977, s.n., 338, 462/II; 10166/IV; 455/VI; s.n., BRI 261555, 1538, 1959/VII.—*K.J. White* NGF 10045, NGF 10972/II; 1174/IV.—*T.G. White* s.n., BRI 260727/II.—*Wiakabu & Kauning* LAE 73313/IV.—*Wilcox* s.n., MEL 97706, MEL 97721/VII.—*Williams* 78094/IV.—*Winchel* 1636B, s.n./II.—*Womersley* 4323/VI.—*Womersley & Floyd* 6806/VII.—*Wood* s.n./II.—*Wrigley & Telford* 380, 524, 690/II.—*Wycliff* s.n., MEL 97604/IV.—*Yate* 1604,3025/II.—*Zippelius* s.n., BRI 261614/II.—*Zollinger* 3181/II.

Index to Scientific Names

Names

New names and combinations are in **bold**. Synonyms, misapplied, misspelt, illegitimate or invalid names are in *italics*.

Page numbers

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A TAXONOMIC REVISION OF THE GENUS *IXODIA* (ASTERACEAE)

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Abstract

The endemic Australian genus *Ixodia* is revised and two species are recognized, namely *I. achillaeoides* R. Br. in Ait. f. and *I. flindersica* Copley, sp. nov. In addition, 3 subspecies of *I. achillaeoides*, namely ssp. *achillaeoides*, ssp. *alata* (Schltdl.) Copley and ssp. *arenicola* Copley are recognized. Keys, descriptions, illustrations and distribution maps are provided, together with notes on ecology.

Nomenclatural History of the Genus

The genus *Ixodia* was first collected by Robert Brown at Memory Cove near Port Lincoln (South Australia) in February, 1802. It was subsequently briefly described by him in the manuscript of his Australian collections and given the name *Ixodia gnaphaloides*. However, Brown did not deal with the Asteraceae in his 'Prodromus' (1810), and this name was never published.

The first published diagnosis of *Ixodia* appeared in W.T. Aiton's "Hortus Kewensis" in 1812. Aiton (1812) acknowledged that the generic name had been supplied by Brown, and in fact Bennett (1866) attributed the compilation of the Compositae, among other families, to Robert Brown.

Sims in Curtis's Botanical Magazine (1813), stated that Brown was the author of this species. The correct author citation for *Ixodia* should therefore be R. Br. in Ait. f. This is in accordance with the International Code of Botanical Nomenclature (1978, p 40), which states that "when a name with a description or diagnosis (or reference to a description of a diagnosis) supplied by one author is published in a work by another author, the word *in* should be used to connect the names of the two authors". Until now the accepted citation has been R. Br. ex Ait. which failed to give Brown credit for the diagnosis and also failed to show that Aiton the younger was responsible for the publication.

The validly published type species for the genus is *I. achillaeoides*, published by Aiton in 1812. However, in Curtis's Botanical Magazine (1813), Sims omitted a letter *a* from the specific epithet, resulting in the spelling '*achilleoides*'. This latter spelling was subsequently adopted by De Candolle (1837) and Schlechtendal (1847), and used in nearly all references to this species until Eichler (1965) corrected it in his 'Supplement to J.M. Black's Flora of South Australia'.

Only the single species, *I. achillaeoides*, was orginally recognized. Subsequently, Sprengel (1827) transferred *Ammobium alatum* to *Ixodia* as *I. ammobium* but apparently no later workers accepted this change (Orchard, 1982). *Ammobium* is currently recognized as a genus consisting of two species, allied, but not necessarily closely related, to *Ixodia* (Orchard, 1982).

In 1847, Schlechtendal described a new species, *Ixodia alata*, from a specimen collected by Dr Behr in the Barossa Ranges near Tanunda, South Australia. He distinguished this species from *I. achillaeoides* by its larger stature, longer and broader leaves and greater degree of leaf base decurrence forming wings down the stem.

Another species, *I. ptarmicoides*, was described by Mueller in 1853 from specimens

collected by Carl Wilhelmi between Mount Dutton and Coffin Bay on Eyre Peninsula, South Australia. Mueller claimed that this species had a smaller stature and thicker shorter leaves which were less glutinous and less decurrent than *I. alata*. He also distinguished it from *I. achillaeoides* by its thicker, more obtuse leaves and more obtuse spathulate involucral bracts.

Both *I. alata* and *I. ptarmicoides* were accepted by Sonder (1853). However, in 1866 Bentham relegated them to synonymy in *I. achillaeoides*, pointing out that the species has two forms, "of which the extremes look very different, '*I. achillaeoides*', with narrow leaves, obtuse or with recurved points, not very decurrent, and with small flower-heads, and '*I. alata*' with broader, more acute and more decurrent leaves and larger flower-heads". But, he continued, "there are many specimens equally referable to the one or to the other". Bentham and Hooker (1873) and Black (1929) followed this recognition of a single, monotypic, but variable genus.

In 1931, Ewart sought to recognize the south-western Victorian plants with broader leaves and larger capitula as *I. achillaeoides* var. *alata* (Schltdl.) Ewart, but Willis (1972) pointed out that "there seems to be no sharp line of demarcation between var. *alata* and the typical form (Eyre Peninsula, S. Aust.)".

While preparing a paper on the subgenus *Ozothamnus* of the genus *Helichrysum* Burbidge found that the Tasmanian species *Helichrysum angustum* Wakefield had been generically misplaced. This species has long receptacular scales between the florets and lacks a pappus, and for these reasons Burbidge (1958) placed it in the genus *Ixodia* as *I. angusta.*

In 1977 Morris described a further Tasmanian species, *I. achlaena*, which lacks a pappus. This species also lacks receptacular bracts but, as in *I. achillaeoides*, a "pseudo-pappus" ring of pappillae is present.

Orchard (1982), however, has recently reviewed the generic affinities of the Tasmanian species of *Ixodia* and concludes that they show as great, if not more, similarity to *Haeckeria* and *Cassinia* than they do to *Ixodia achillaeoides* and, for this reason, has segregated them as a new genus *Odixia.*

The genus *Ixodia* has, therefore, once again come to be considered as monotypic but in the present revision a new species is described from the Northern Flinders Ranges, South Australia, and the type species, *I. achillaeoides*, is subdivided into three easily recognized subspecies.

IXODIA R. Br. in Ait. f.

Ixodia R. Br. in Ait. f., Hort. Kew. 2nd ed., 4: 517 (1812); Curtis's bot. Mag. t. 1534 (1813); DC. Prodr. 6: 154 (1837); Benth., Fl. Austral. 3: 582 (1866); Benth. in Benth. & Hook. f., Gen. Pl. 2: 318 (1873); Ewart, Fl. Vict. 1144 (1931).

Type: *I. achillaeoides* R. Br. in Ait. f., Hort. Kew, 2nd ed., 4: 517 (1812).

Shrub to 3.5 m high, decumbent, ascending or erect, glabrous. *Leaves* alternate, sub-erect or spreading, sessile to decurrent, narrow-linear, linear, narrowly rhombic or obovate, usually dark-green above, light-green below, glabrous to slightly sericeous-woolly, viscid, apices acute to obtuse, often with recurved tips; margins entire, flat or revolute; midvein usually impressed above, prominent below. *Inflorescence* terminal, corymbose, with few to many capitula; *capitula* homogamous, discoid, sessile to shortly pedunculate, ovoid, depressed-ovoid, urceolate or cylindrical, (3-) 4-9 (-10) mm long (1-) 2-8 mm wide (excluding the radiating laminae) with (17-) 20-50 (-54) imbricate, appressed, light-green, brown or reddish-brown, cartilaginous, glabrous or sericeous-

woolly involucral bracts; *outer involucral bracts* usually in 2-4 whorls, appressed over lower three-quarters, slightly recurved distally, spathulate, narrowly elliptic, narrowly obovate or obovate, acute to obtuse, 1-6 mm long, 0.5-2.5 mm wide; *inner involucral bracts* usually in 2 whorls, spathulate to narrowly obovate or obovate with conspicuous radiating white scarious petaloid laminae from about one quarter to one half the length of their narrow erect claws; *laminae* acute to obtuse, glabrous or covered on the adaxial surface by simple, subcylindrical, somewhat flattened, eglandular hairs; *receptacle* conical, bearing chaffy involute scales or cartilaginous petaloid bracts enveloping or subtending each floret. *Florets* often slightly exserted; corolla tubular, bisexual, 5-toothed, usually with glandular hairs on the abaxial surfaces of the teeth, cream, yellow or reddish; style terete, bifurcate, the base uninflated; stamens 5; anthers linear-caudate. *Achene* 3- to 4-angled, glabrous or papillose-pubescent, narrowly oblong, oblong or obovate; pappus absent; 'pseudo-pappus' or membranous rim with simply, erect (papillae) projecting from it.

Distribution

The genus *Ixodia* is restricted to southern mainland Australia, with one species endemic to the northern Flinders Ranges (South Australia) and one species widespread in southern South Australia and south-western Victoria.

Affinities

Ixodia is allied to *Ammobium* R. Br. and *Odixia* A.E. Orchard due to the presence of a receptacular bract subtending each floret, except in *O. achlaena* (D.I. Morris) A.E. Orchard, and the presence of a pseudopappus ring or cup at the summit of the achene, except in *O. angusta* (N.A. Wakefield) A.E. Orchard. However, it differs from these genera in the number of florets per capitulum, the number of capitula per inflorescence and the form of capitulum disintegration and achene shedding. Affinities with, and differences to, species in *Helichrysum* subgenus *Ozothamnus* and *Cassinia* sect. *Rhynea* have been discussed by Orchard (1982).

Key to the Species

1a. Laminae of inner involucral bracts glabrous; each floret enveloped by a scarious receptacular scale; achene papillose-pubescent .... *I. achillaeoides*

1b. Laminae of inner involucral bracts covered with simple flattened sub-cylindrical hairs on their adaxial surface; each floret subtended and partially enveloped by a cartilaginous, petaloid, bract-like scale; achene glabrous .... *I. flindersica*

4, (see reference, p. 54;

1. **Ixodia achillaeoides** R. Br. in Ait. f., Hort. Kew. 2nd ed., 2: 517 (1812). Black, Fl. S. Austr. 2nd ed., 919 (1957) pro parte (excluding specimens from Flinders Ranges).

Type: *Brown s.n.*, Bay xi, South Coast, (Memory Cove near Port Lincoln, South Australia), (K, 3 spec., syn.; photo!).

Shrub to 2 m high, erect or dwarfed and compact, branching in upper part, glabrous. *Leaves* variable (see detailed descriptions of infra-specific taxa), alternate, more or less decurrent, often forming a wing down the stem, narrow-linear, linear, narrowly rhombic or obovate, dark green above, paler below, glabrous, viscid; apex acute to obtuse, often with a recurved tip, margins entire, usually flat. *Inflorescence* corymbose, terminal with 3-80 capitula; *capitula* urceolate to ovoid (3-) 4-9 mm long, (1-) 2-8 mm wide with (17-) 20-40 (-54) imbricate, light-green to brown cartilaginous, glabrous or sericeous-woolly involucral bracts; *outer involucral bracts* narrowly oblong to narrowly elliptic, acute to

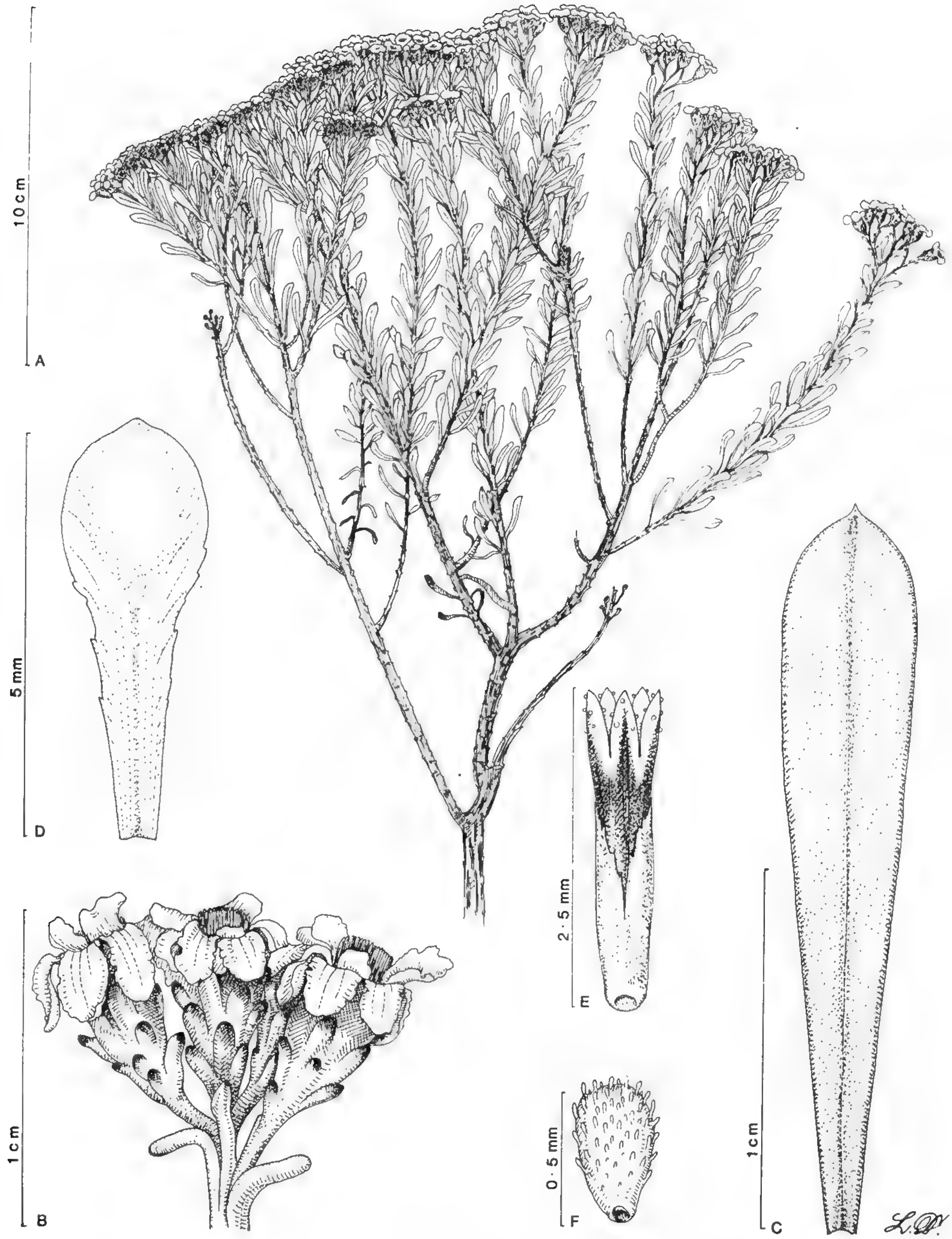

Fig. 1. *Ixodia achillaeoides* ssp. *achillaeoides*. A, habit; B, inflorescence; C, typical leaf; D, inner involucral bract with radiating lamina; E, floret with receptacular scale; F, achene (from *D.N. Kraehenbuehl 870*, Stenhouse Bay).

obtuse; inner involucral bracts spathulate, with white, papery, petaloid obtuse to bluntly acute, glabrous laminae about half the length of their narrow cartilaginous claws; *receptacle* conical, bearing chaffy involute scales (sometimes with a petaloid tip) subtending and enveloping each floret. *Florets* usually slightly exserted; corolla cream or green tinged with red; style-base not inflated. *Achenes* 4-angled, narrowly oblong to oblong, papillose-pubescent; pappus absent.

Distribution (Figs 2, 4 and 6)

I. achillaeoides consists of three subspecies which occur in southern South Australia and south-western Victoria.

Key to the Subspecies of *I. achillaeoides*

1a. Leaves narrow-linear, linear, narrowly rhombic, or lanceolate; plants found in inland habitats .... 1c. ssp. *alata*

1b. Leaves oblanceolate to obovate; plants found in coastal habitats 2

2a. Leaves oblanceolate, less than 5 mm wide; capitula urceolate, less than 5.5 mm long and 4.0 mm wide; laminae of 2-4 mm long, 1-2 (-3) mm wide .... 1a. ssp. *achillaeoides*

2b. Leaves obovate, greater than 6 mm wide; capitula sub-globose to globose, greater than 6.0 mm long and 6.5 mm wide; laminae of 4-6 mm long, 3-5 mm wide .... 1b. ssp. *arenicola*

1a. ssp. **achillaeoides**

Ixodia achillaeoides R. Br. ex Ait. f., Hort. Kew. 2nd ed., 4: 517 (1812); Curtis's bot. Mag. t. 1544 (1813); DC., Prodr. 6: 154 (1837).

Shrub ascending to erect, often dwarfed and compact, 10-80 cm tall. *Leaves* oblanceolate to narrowly obovate, 4-35 (-40) mm long, 0.5-5 mm wide, with bases more or less decurrent onto the branches, coriaceous to fleshy, more or less viscid. *Capitula* urceolate, 4.0-5.5 mm long, (1.8-) 2-4 mm wide; laminae of inner involucral bracts 2.0-4.0 mm long, 1.0-2.0 (-3.0) mm wide. (Fig. 1).

Distribution (Fig. 2).

This subspecies occurs along the southern coastline of Yorke and Eyre Peninsulas, the southern and western coastlines of Kangaroo Island and on some of the nearby islands (e.g. Wedge Island).

Comments

I. achillaeoides ssp. *achillaeoides* is a strictly coastal taxon growing on coastal cliffs and exposed coastal sand dunes. Specimens collected from Cape Spencer on Yorke Peninsula (*P.B. Copley 143*) and from Cape Gantheaume on Kangaroo Island (*P.B. Copley 57*) were found to have chromosome numbers of n = 13.

Selection of Specimens examined (77 seen)

SOUTH AUSTRALIA: Eyre Peninsula: *Alcock 931*, "West Point", hundred of Flinders, c. 15 km south of Port Lincoln, 31.i.1966 (AD); *B. Copley 2455*, Cape Wiles, 25.i.1969 (AD); *Specht 2701*, Flinders Flora and Fauna Reserve, c. 15 km south-south-east of Port Lincoln, 10.xi.1960 (AD); *Spooner 3265*, Lincoln National Park, 7.i.1974 (AD); *Williams 2099*, Cape Wiles, 16.iv.1965 (AD).

Yorke Peninsula: *Blaylock 454*, Pondalowie Bay, 27.iii.1967 (AD); *P.B. Copley 142-146*, 14.2 km north-east of Marion Bay on Warooka road, 19.iii.1977 (AD); *Donner 457*, c. 8 km north of Marion Bay, 23.iv.1962 (AD); *Kraehenbuehl 870*, Stenhouse Bay, 6.i.1963 (AD); *Major 47*, Wedge Island, 1973 (AD); *Simpson s.n.*, Pondalowie Bay, December, 1928 (AD-); *Rounsevell 16*, Wedge Island, 15.v.1969 (AD).

Kangaroo Island: *P.B. Copley 57-68*, Cape Gantheaume Conservation Park, 6.iii.1977 (AD); *P.B. Copley 84-88*, mouth of South-West River, 7.iii.1977 (AD); *Eichler 15391*, Cape du Couedic (near the lighthouse),

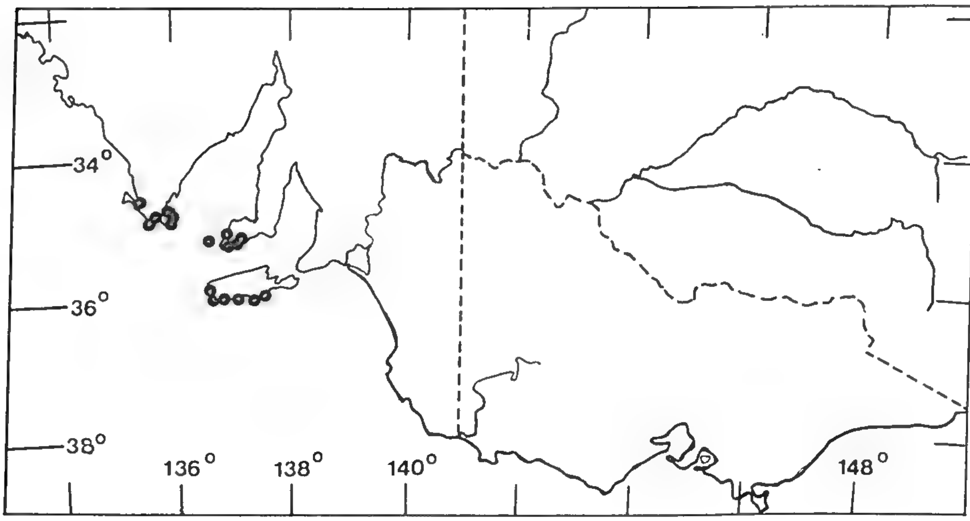

Fig. 2. Distribution of *Ixodia achillaeoides* ssp. *achillaeoides*

11.xi.1958 (AD); *Ising s.n.*, D'Estree's Bay, January, 1923 (AD 97020244); *Kraehenbuehl 6*, sandhills at Seal Bay, 2.i.1958 (AD); *Lothian 792*, Seal Bay, facing sea, 10.i.1962 (AD); *Schodde 519*, Cape du Couedic lighthouse, 27.xii.1957 (AD).

1b. ssp. **arenicola** Copley, ssp. nov.

Frutex decumbens vel adscendens, 35-50 cm altus. *Folia* obovata, 10-30 mm longa, 6-10 mm lata, basis plus minusve decurrentibus in ramulos, coriacea, plus minusve viscida. *Capitula* subglobosa vel globosa, 6.0-7.5 mm longa 6.5-7.5 mm lata; bractearum involucratarum interiorarum laminae lata obovatae, 4-6 mm longae, 3-5 mm latae.

Holotype: *D. Hunt 1883*, Port MacDonnell, c. 25 km south of Mt Gambier, 14.ii.1964 (AD).

Shrub decumbent or ascending, 35-50 cm tall. *Leaves* obovate, 10-30 mm long, 6-10 mm wide, with bases decurrent onto the branches, coriaceous more or less viscid. *Capitula* sub-globose to globose, 6.0-7.5 mm long, 6.5-7.5 mm wide; laminae of inner involucral bracts broadly obovate, 4-6.0 mm long, 3-5 mm wide (Fig. 3).

Distribution (Fig. 4).

I. achillaeoides ssp. *arenicola* is only known from small areas on the coast near Portland, Victoria and Douglas Point, west-north-west of Port MacDonnell in the south-east of South Australia.

Comments

This subspecies is possibly only a clinal extension of what is here recognized as *I. achillaeoides* ssp. *alata*, but for the present it is distinguished by its larger and broader obovate leathery leaves. Specimens available and ascribed to ssp. *arenicola* appear quite distinct, but further studies are needed.

Specimens examined

SOUTH AUSTRALIA: South Eastern Region: *Cleland s.n.*, Point Douglas c. 15 km west-north-west of Port MacDonnell, 15.ii.1948 (AD 97227046); *P.B. Copley 208*, Point Douglas, South-East, S.A., 25.iii.1978;

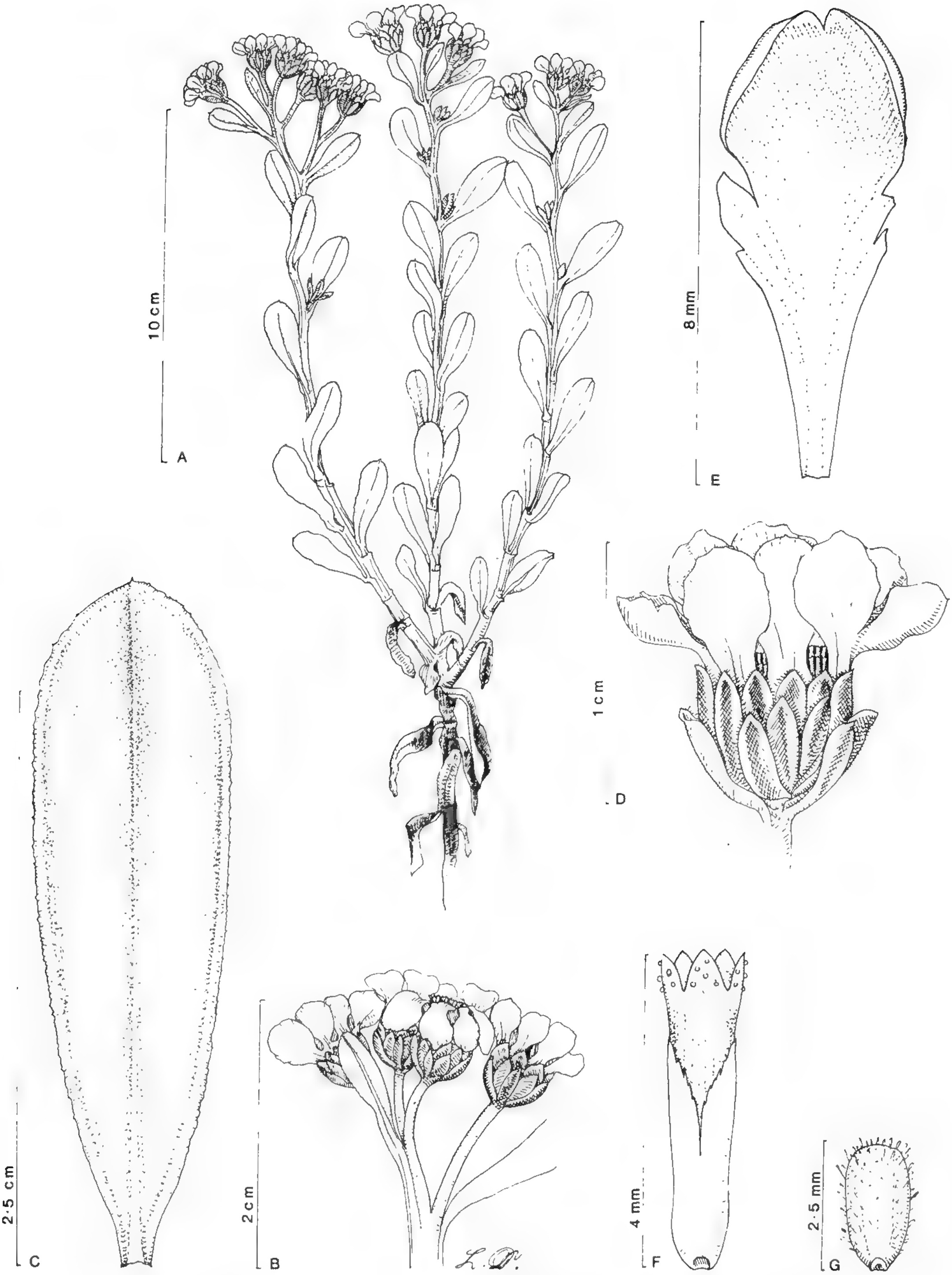

Fig. 3. *Ixodia achillaeoides* ssp. *arenicola*. A, habit; B, inflorescence; C, typical leaf; D, capitulum; E, inner involucral bract with radiating lamina; F, floret with receptacular scale; G, achene (from *D. Hunt 1883*, Port MacDonnell).

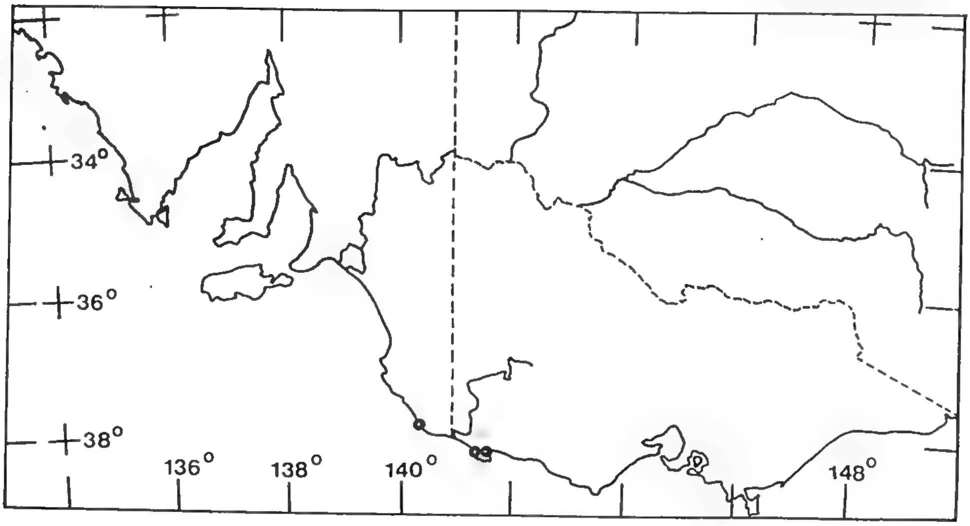

Fig. 4. Distribution of *Ixodia achillaeoides* ssp. *arenicola*.

Hunt 1883, Port MacDonnell, c. 25 km south of Mt Gambier, 14.ii.1964; *Mitchell s.n.*, Point Douglas, South-East, South Australia, 28.i.1978 (AD 97824002).

VICTORIA: South-west coast: *Bates 910*, coast near Alcoa Aluminium Smelter, Portland, 20.ii.1981; *A.C. Beauglehole 20127*, along coast, Bridgewater, Portland, Victoria, i.1945.

1c. ssp. **alata** (Schltdl.) Copley, stat. nov.

Ixodia alata Schltdl. in Linnaea 20: 593 (1847); Sond. in Linnaea 25: 495 (1852) Basionym.

Type: *Behr s.n.*, Barossa Ranges, (K, 1 spec., photo!).

Ixodia achillaeoides var. *alata* (Schltdl.) Ewart, Flor. Vict. 1144 (1931); Willis, Pl. Vict. 2: 725 (1972).

Ixodia ptarmicoides F. Muell. in Linnaea 25: 405 (1852).

Shrub, erect to 2 m. *Leaves* narrow-linear, linear, narrowly rhombic or lanceolate, 5-80 (-100) mm long, 1-10 mm wide, leaf-base decurrent, often forming wings down the stem, herbaceous, viscid. *Capitula* urceolate to sub-globose, 3.0-7.5 mm long, 1.5-5.0 cm wide; laminae of inner involucral bracts 1.0-5.0 mm long, 1-0-4.0 mm wide. (Fig. 5).

Distribution (Fig. 6)

This subspecies occurs on southern Eyre Peninsula, southern Yorke Peninsula, in the northern and southern Lofty regions, on Kangaroo Island, in the south-eastern region of South Australia, in the Grampians and along the south-west coast of Victoria from the mouth of the Glenelg River to Anglesea. A specimen was also collected by Captain S.A. White at Mobilong in the Murray Region of South Australia in 1884.

Comments

I. achillaeoides ssp. *alata* is a highly variable taxon with several recognisable leaf forms. At one extreme of this range of variation are plants with narrow, linear leaves and relatively small urceolate capitula, 30-40 mm long and 2.0-2.5 mm wide. At the other extreme are plants with broad-linear to lanceolate, decurrent leaves with

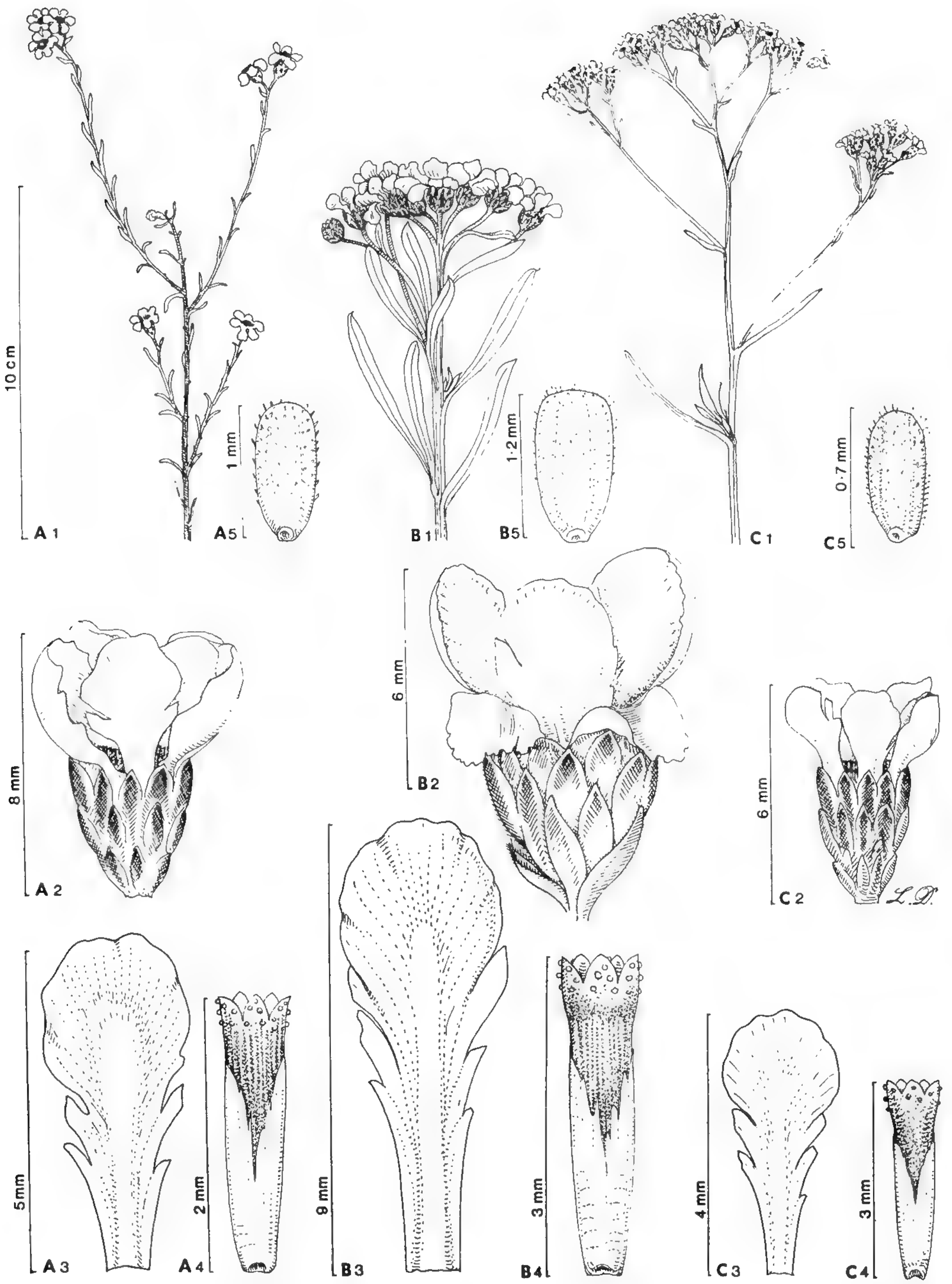

Fig. 5. *Ixodia achillaeoides* ssp. *alata*. A1, B1, C1, habit; A2, B2, C2, capitulum; A3, B3, C3, inner involucral bract with radiating lamina; A4, B4, C4, floret with receptacular scale; A5, B5, C5, achene (from A: *P.B. Copley 97*, adjacent to South West River Bridge, Kangaroo Island; B, *Melville 1687*, between Gorae West and Mt Richmond; C, *R.L. Specht s.n.*, 1 mile north-west of Millbrook Reservoir).

pronounced wings down the stems and relatively large suborbicular capitula, 5.0-6.0 mm long and 4.0-5.0 mm wide. The latter extreme grows in open stringybark (*Eucalyptus baxteri - E. obliqua*) forest communities on relatively deep sands and loams in the Mt Lofty Ranges of South Australia and south-western Victoria. The former, occurs mainly on skeletal calcareous or lateritic soils in a variety of plant communities on Kangaroo Island and southern Yorke and Eyre Peninsulas in South Australia. With more work several taxa may eventually be recognized in this group. However, the range of variation appears to be part of a clinal continuum. This is particularly evident on Kangaroo Island where virtually the entire range of variation occurs. Karyotypic studies may help to determine relationships.

Selection of Specimens examined (258 seen)

SOUTH AUSTRALIA: Eyre Peninsula Region: *B. Copley 2889*, crest of ridge behind Wharminda, 4.i.1973 (AD); *Jericho 3*, Whalers' Bay area, Thistle Island, 24.ii.1975 (AD); *Specht 2023*, west of section 6, Hundred of Verran, Blue Range, 9.xii.1959 (AD).

Northern Lofty Region: *Donner 1048*, Humbug scrub, 14.iv.1963 (AD); *Donner 4763*, Black Hills, c. 15 km east of Burra, 23.iv.1974 (AD).

Murray Region: *S. Dixon s.n.*, Mobilong, 16.v.1884 (AD 97625387).

Yorke Peninsula Region: *B. Copley 4340*, c. 2 km east of Innes National Park Headquarters, 27.vii.1974 (AD); *Weber 4319*, between Pondalowie Bay and Shell Beach, 11.x.1974 (AD).

Southern Lofty Region: *Cleland s.n.*, Goolwa, 14.xii.1940 (AD 97227050); *Cooper s.n.*, c. 8 km north of Tunkalilla Beach which is c. 30 km west-south-west of Victor Harbor, 28.xii.1942 (AD 96229005); *P.B. Copley 6-10, 15*, southern boundary of Kyeema Conservation Park, 12.ii.1977 (AD); *P.B. Copley 23-29*, Boundary Road, near Carey Gully, 21.ii.1977 (AD); *Gardiner s.n.*, Para Wirra, near Elizabeth, March, 1962 (AD 96236126).

Kangaroo Island: *P.B. Copley 32-36*, c. 7 km east of Penneshaw rubbish dump, Dudley Peninsula, 4.iii.1977 (AD); *P.B. Copley 41-45*, c. 2 km from bitumen on road to South Coast Road from American River, 5.iii.1977 (AD); *P.B. Copley 108-112*, Harriet River crossing on east-west road north of Mt Taylor, 7.iii.1977 (AD); *P.B. Copley 121-125*, Scott's Cove Lookout, near Cape Borda, 8.iii.1977 (AD); *P.B. Copley 126-130*, Ravine des Casoars, north of West Bay, 8.iii.1977 (AD); *Jackson 898*, Stunsail Boom River, 14.xi.1977 (AD).

South-Eastern Region: *Hunt 641*, near Wolseley, east of Bordertown, 9.i.1962 (AD); *Sharrad 566*, c. 40 km south of Salt Creek, 15.iv.1960 (AD); *Williams 3466*, "Log Crossing" near "Cantara", Kingston, 2.xii.1969 (AD).

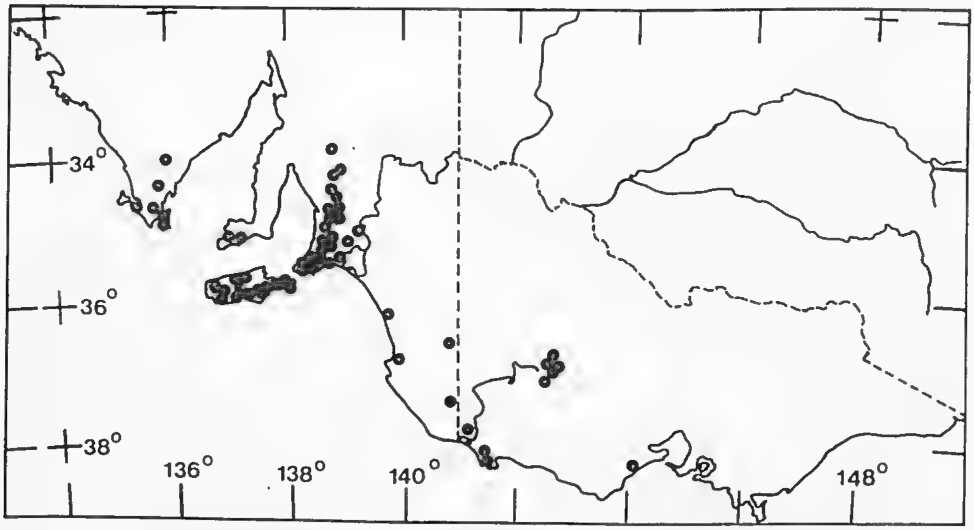

Fig. 6. Distribution of *Ixodia achillaeoides* ssp. *alata*.

VICTORIA: Grampians Ranges: *Ingwusen s.n.*, near kiosk, McKenzies Fall, Grampians, 10.ii.1965 (CANB 011095); *Ising 2317*, Mt Victoria, Grampians, 6.i.1927 (AD); *P. Mathews s.n.*, South of Moora-Moora Reservoir, Victoria Valley, Grampians, x.1976 (MEL 523910); *F. Robbins s.n.*, Mt Victory Creek, Grampians, i.1940 (MEL 520840); *Sharrad 1272*, Hall's Gap, Grampians, 19.i.1962 (AD); *Warcup s.n.*, Wonderland track below the "Wall of China", Grampians, 19.i.1961 (ADW 23661).

South-West Coast: *J. Anderson 362*, 12 miles south-west of Portland, along coast at Cape Nelson, 22.i.1969; *H.I. Aston 744*, northern boundary of Mt Richmond National Park, 22.x.1960.

2. **Ixodia flindersica** Copley, sp. nov.

Frutex 15-40 cm altus, ramis ascendentibus glabris. *Folia* crebro alterna in ramis junioribus, absentia ab senioribus, sessilia, linearia usque anguste vel elliptica, 5-25 (-50) mm longa, 0.5-4.0 (-7.0) mm lata, herbacea ad cartilaginea, atroviridia nitidaque supra, pallida infra, viscida; apex acutus; margo integra, plana; costa leviter impressa supra, prominens infra. *Inflorescentia* corymbosa terminalis, (1-) 2-6 capitulis, constans; *capitula* obovoidea usque cylindrica, (5-) 6-8 (-10) mm longa (3-) 4-6 (-7) mm lata, (25-) 30-50 bracteis involucralibus imbricatis pale viridibus vel testaceis, cartilagenis, glabris; *bracteae involucrales exteriores* ad tres quadrantes inferiores longitudinis appressae distale parum recurvatae, anguste oblongae usque anguste ellipticae, acutae; *bracteae involucrales interiores* spatulatae, laminis circiter $^1/_4$ longitudinis bracteae, alba, chartacea, petaloidea, acuta, pilis eglandulosis, simplicibus, subcylindricis, plus minusve complanatis, interdum lamina libris, interdum ad laminam perfecteve adnatis, in pagina adaxiali tecta; *receptaculum* conicum, bractea angusta unuquemque flosculum subtenenti; bracteae receptaculares involucralibus interioribus similes sed marginibus incurvatis ut basim flosculi amplextuntur partim circumcingent. *Flosculi* (30-) 40-70 (-110) in capitula quoque, pilis glandulosis in pagina abaxiali loborum corollae. *Achenia* 3- vel 4-angula, anguste oblonga usque obovata, circa 1.0-2.0 mm longa circa 0.2-0.7 mm lata, glabra; pappus cupuliformis, non profundus, breviter ciliatus. *Plantula* foliis rhombicis, 30-40 mm longis, 7-10 mm latis, herbaceis, supra glabris, infra leviter pilosis, non viscidis.

Holotypus (Fig. 7): *Lothian 3147*, southern slope of Mt Serle, Flinders Range, South Australia, 10.xi.1964 (AD 96503124).

Shrub 15-40 cm high, with ascending, glabrous branches. *Leaves* closely alternate on younger branches, absent from older branches, sessile, linear to narrowly-rhombic or elliptic, 5-25 (-50) mm long, 0.5-4.0 (-7.0) mm wide, herbaceous to cartilaginous, dark green and shiny above, pale below, viscid; apex acute; margins entire, flat; midvein slightly impressed above, prominent below. *Inflorescence* corymbose, terminal with (1-) 2-6 capitula; *capitula* obovoid to cylindrical, (5-) 6-8 (-10) mm long, (3-) 4-6 (-7) mm wide, with (25-) 30-50 imbricate, light-green to yellowish-brown cartilaginous, glabrous involucral bracts; *outer involucral bracts* appressed over lower three-quarters, slightly recurved distally, narrowly oblong to narrowly elliptic, acute; *inner involucral bracts* spathulate, with white, papery, petaloid, sharply to bluntly acute laminae about one-quarter of the length of the bracts and covered on their adaxial surface with simple, subcylindrical, somewhat flattened, eglandular hairs, sometimes free from lamina, sometimes partially or completely adnate to it; *receptacle* conical, bearing a narrow bract subtending each floret; receptacular bracts resembling inner involucral bracts but with margins incurved to clasp and partially surround base of floret. *Florets* (30-) 40-70 (-110) in each capitulum with glandular hairs on abaxial surface of corolla lobes. *Achenes* 3-4 angled, narrowly oblong to obovate, c. 1.0-2.0 mm long and 0.2-0.7 mm wide, glabrous; pappus a shallow, shortly ciliate cup (a "pseudo-pappus"). *Seedling* with rhombic leaves, 30-40 mm long, 7-10 mm wide, herbaceous, glabrous above, slightly pilose below, not viscid. (Fig. 7).

Distribution (Fig. 8).

I. flindersica is only known from the northern Flinders Ranges of South Australia from Ann Hill and Patawerta Hill in the south to Freeling Heights in the north.

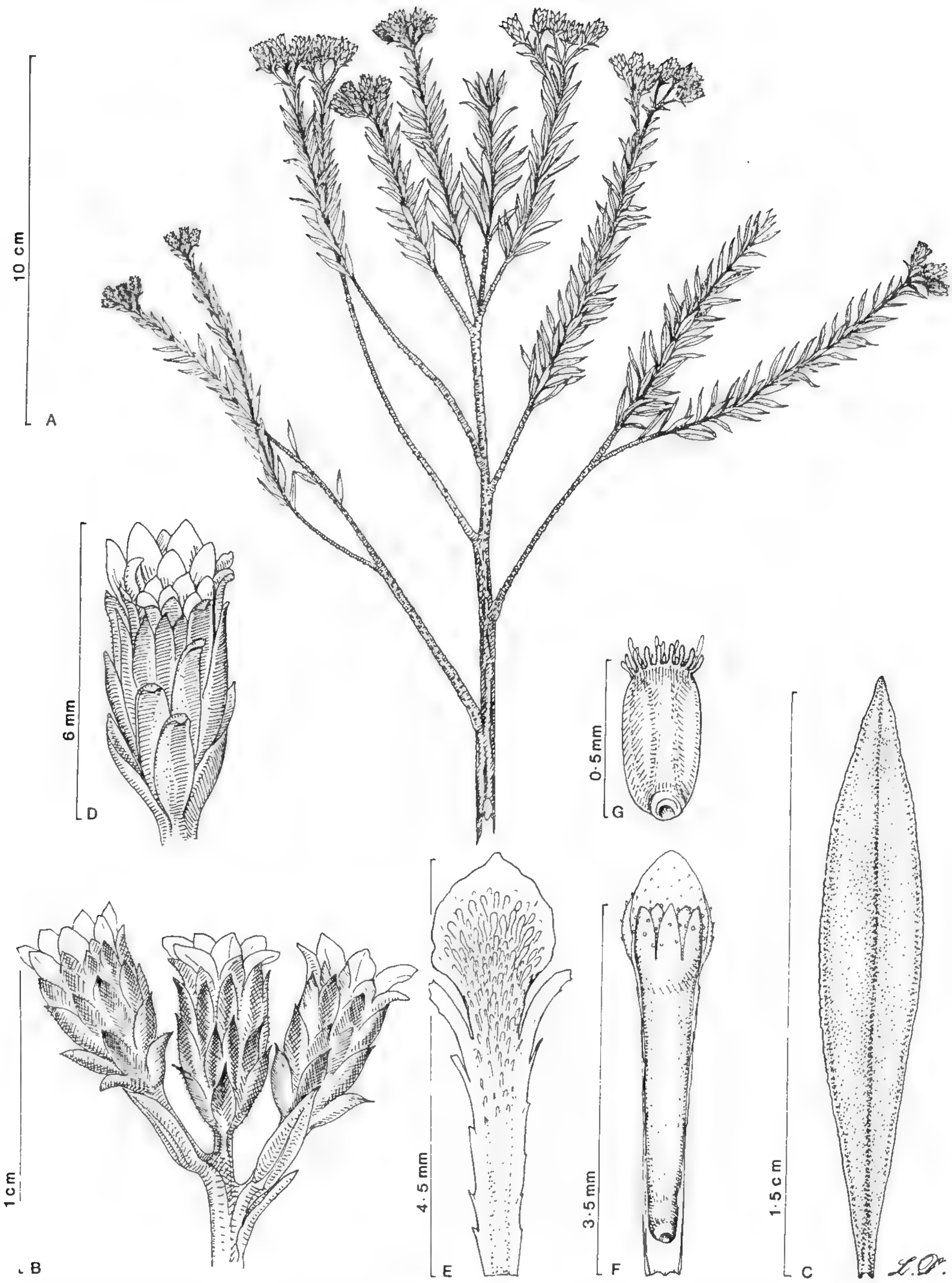

Fig. 7. *Ixodia flindersica.* A, habit; B, inflorescence; C, typical leaf; D, capitulum; E, inner involucral bract with radiating lamina; F, floret with receptacular bract-like scale; G, achene (from *Lothian 3147*, southern slope of Mt Serle, Flinders Range).

Comments

This species grows in rock fissures on the high rocky slopes of sandstone peaks and ridges in the region mentioned. Some specimens have, however, been observed growing in rocky creekbeds which flow out of the Gammon and Freeling Heights plateaux.

The specific epithet *flindersica* refers to the restricted distribution of this species in the northern Flinders Ranges. The species was also observed, but not collected, on rocky slopes in the Gammon Ranges National Park.

Specimens examined

SOUTH AUSTRALIA: Flinders Ranges: *Cleland s.n.*, slopes of Mt Serle, c. 45 km east of Leigh Creek, 31.v.1936 (AD 97227044); *P.B. Copley 153-155, 174-178*, upper slopes of Mt Serle, 8.iv.1977; *P.B. Copley 415-417*, upper rocky slopes of Patawerta Hill, 1.vi.1980; *P.B. Copley 418*, upper rocky slopes of Mt Tilley, 1.vi.1980; *P.B. Copley 420*, upper rocky slopes of Mt Andre, 3.vi.1980; *P.B. Copley 421*, upper rocky slopes of Mt Uro, 2.vi.1980; *P.B. Copley 422*, upper rocky slopes of the Cocks Comb, 3.vi.1980; *P.B. Copley 423*, upper rocky slopes of Ann Hill, near Point Well, 4.vi.1980; *P.B. Copley 425*, Balancing Rock, Yudnamutana Gorge, Arkaroola-Mt Painter Sanctuary, 16.vii.1980; *P.B. Copley 430*, Yudnamutana Waterfall, Arkaroola-Mt Painter Sanctuary, 16.vii.1980; *P.B. Copley 441-444, 447*, Freeling Heights, 22.vii.1980; *P.B. Copley 474-476*, Mt Rose, (north of Mt Serle), 30.vii.1980; *P.B. Copley 477*, Mudlapena Gap, Angepena Station, 31.vii.1980; *P.B. Copley 485*, gorge east of Patsy Springs Homestead, 31.vii.1980; *Kraehenbuehl 747*, rocky hills near Mt Serle, 13.x.1962; *Lang 825-827, 830, 831, 836, 837* (*P.B. Copley 184-191*), Mt Hack, 16.v.1977; *Lothian 3147, 3149*, southern slope of Mt Serle, 10.xi.1964; *Symon 3993*, upper slopes of Mt Serle, 4.iii.1966.

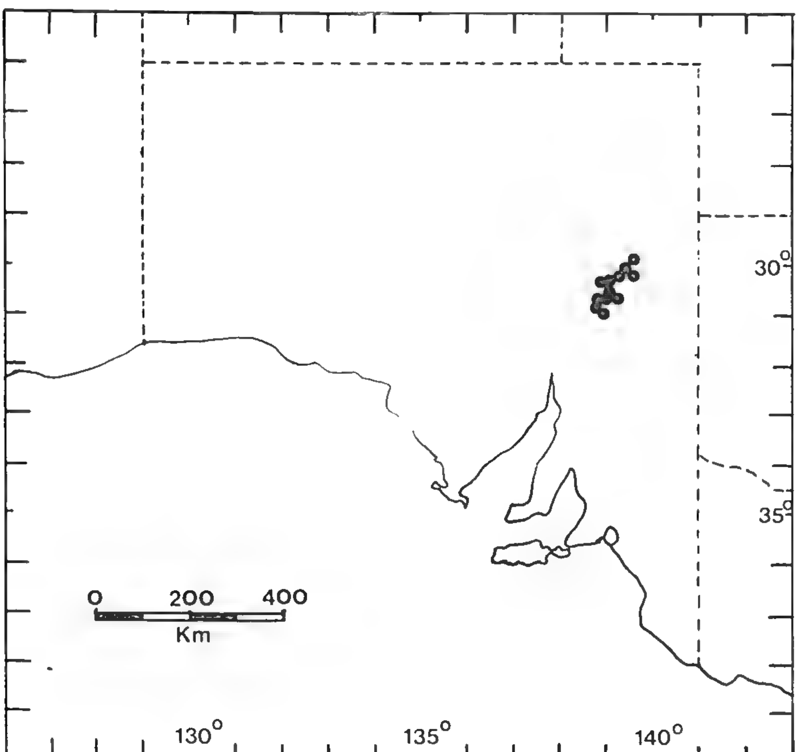

Fig. 8. Distribution of *Ixodia flindersica*.

Acknowledgements

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References

Aiton, W.T. (1812). "Hortus Kewensis" ed. 2, 4: 517. (Longman, Hurst, Rees, Orme and Brown: London).
Bennett, J.J. (Ed.) (1866). The miscellaneous botanical Works of Robert Brown. (Ray. Society: London).
Bentham, G. (1866). "Flora Australiensis". 3: 582. (L. Reeve: London).
Bentham, G. and Hooker, J.D. (1873). "Genera Plantarum" 2: 318. (William Pamplin, Lovell Reeve and Co., Williams and Norgate: London).
Black, J.M. (1929). Compositae. "Flora of South Australia" ed. 1, 4: 570-662. (Government Printer: Adelaide).
Brown, R. (Unpub.). Botanical Descriptions (Manuscript) of Australian Plants held by the British Museum (Natural History). (Positive microfilm: 22 reels at AD).
Brown, R. (1810). "Prodromus Florae Novae Hollandae". (Taylor: London).
Burbidge, N.T. (1958). "Note on a new species of *Ixodia* R. Br. (Compositae)". *Vict. Nat.* 75: 95-96.
De Candolle, A.L.P.P. (1837). "Prodromus Systematis naturalis Regni vegetabilis" 6: 154. (Paris).
Eichler, Hj. (1965). "Supplement to J.M. Black's Flora of South Australia". (Government Printer: Adelaide).
Ewart, A.J. (1931). "Flora of Victoria". (Government Printer: Melbourne).
Morris, D.I. (1977). "Miscellaneous notes on endemic Tasmanian plants in the genera *Olearia*, *Ixodia*, *Xyris*, *Danthonia*, *Tetrarrhena*". *Rec. Queen Vict. Mus.* 55: 1-5.
Mueller, F. von (1853). "Diagnoses et descriptiones plantarum novarum . . . ". *Linnaea* 25: 405.
Orchard, A.E. (1982). "The generic limits of *Ixodia* R. Br. ex Ait. (Compositae—*Inuleae*)." *Brunonia* 4(2): 185-198.
Schlechtendal, D.F.L. von (1847). "Bestimmung und Beschreibung der von Dr. Behr in Südaustralien gesammelten Pflanzen". *Linnaea* 20: 559-672.
Sims, J. (ed.) (1813). *Curtis's Bot. Mag.* 37: t. 1534.
Sonder, O.W. (1853). "Plantae Muellerianae. Compositae." *Linnaea* 25: 450-530.
Sprengel, C. (1827). "Systema Vegetabilium, Curae Posteriores" ed. 16, 4/2. (Göttingen).
Stafleu, W.T. (ed.) (1978). "International Code of botanical Nomenclature". (Bohn, Scheltema & Holkema: Utrecht).
Wakefield, N.A. (1951). "Some revision in *Helichrysum*". *Vict. Nat.* 68: 49-50.
Willis, J.H. (1972). "A Handbook to Plants in Victoria". Vol. 2. (Melbourne Univ. Press: Carlton).

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NOTES ON *DAVIESIA* AND *PULTENAEA* (FABACEAE) IN SOUTH AUSTRALIA

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Abstract

Four new taxa are described, viz. *Daviesia asperula* subsp. *asperula* and subsp. *obliqua*, *D. benthamii* Meissner subsp. *humilis*, and *D. stricta*. The relationship of the first two species to *D. genistifolia* A. Cunn. ex Benth. is discussed in detail. *D. stricta* is compared with its close relative, *D. wyattiana*, from the east coast. A new combination is made for the tribe Mirbelieae (Benth.) Polhill et Crisp. *Pultenaea elachista* (F. Muell.) comb. nov. is transferred from *Gastrolobium*.

Tribe **Mirbelieae** (Benth.) Polhill et Crisp*, comb. et stat. nov.

Podalyrieae subtribe *Mirbeliinae* Benth., Enum. Pl. Huegel, 35 (April 1837), as 'Mirbelieae'.—*Mirbelieae* (Benth.) Polhill in Polhill et Raven, Advances Legume Syst., 391 (1981), *comb. non rite publ.*—Type: *Mirbelia* Sm.

Podalyrieae subtribe *Pultenaeinae* Benth., *loc. cit.* p. 30, as 'Pultenaeae'.—Type: *Pultenaea* Sm.

Polhill (1981) has made this combination previously but unfortunately his reference to the base name is not to its original publication, and therefore his combination is invalid. Bentham originally published the base name 'subtribus Mirbelieae' in 'Enum. Pl. Huegel' in April 1837 (Stafleu & Cowan 1976, 751), just two months before he published the same name in his 'Commentat. Legum. Gener.' in June 1837 (Stafleu & Cowan 1976, 175). It is to the latter that Polhill (1981) refers.

Daviesia asperula Crisp, sp. nov.

A *D. genistifolia* A. Cunn. ex Benth. phyllodiis ramulisque asperulis, phyllodiis plerumque in plano verticali compressis vel complanatis, et seminibus late ovoideo-ellipsoideis, arillo crasse bilobo differt.

Type: 6-7 miles [10-11 km] from Rocky River, towards Cape Borda, Kangaroo Island, South Australia, *M.E. Phillips s.n.*, 29.ix.1965 (*holo*: CBG 021582; *iso*: AD).

The specific epithet is diminutive of the Latin *asper* (rough) and refers to the slight roughness of the branchlets and phyllodes.

Compact or spreading *shrub* to 2 m tall. *Branchlets* with several longitudinal minutely scabrid ribs. *Phyllodes* arranged spirally, often crowded, spreading, recurved at least at base, vertically compressed or flattened, either subulate or obliquely falcate to narrow-obovate, pungent, articulate at base, 5-25 x 1-4.5 mm, scabridulous, striate with parallel nerves. *Racemes* 1 per axil, 2-3-flowered; rhachis almost nil. *Pedicel* 1-2 mm long. *Calyx* campanulate, with very short subequal lobes. *Corolla*: *standard* very broad-ovate, emarginate, 7-8 mm long and broad including the c. 1 mm claw, orange or yellow with a deep red centre; *wings* narrow-obovate, auriculate, c. 5.5 x

*To be cited as 'Polhill et Crisp', not 'Polhill et Crisp ex Crisp'.

c. 2 mm including the 1.5-2 mm claw, red; *keel* obliquely obovate, beaked, auriculate, saccate, c. 4.5 x c. 2 mm including the 1.5-2 mm claws, red. *Stamens* free, slightly dimorphic. *Pod* broad-obtriangular, constricted to a slighly elongated, stipe-like base, 10-14 x 7-10 mm. *Seed* broad-ovoid-ellipsoid, 3.3-4.0 mm long, 2.4-3.3 mm broad, c. 2.4 mm thick; *aril* thickly 2-lobed, projecting beyond outline of seed in profile. (Fig. 1).

Distribution (Map 1).

South Australia: Eyre Peninsula, Kangaroo Island and Fleurieu Peninsula.

Habitat

D. asperula is found on poor soils, either sand or laterite, in mallee (dominated e.g. by *Eucalyptus cneorifolia*) or open-forest (dominated by *E. cladocalyx*).

Affinity

D. asperula is closely related to *D. genistifolia*. The resemblance is particularly close in the subulate-leaved form of *D. asperula* (= subsp. *asperula*, below). *D. genistifolia* is readily distinguished from *D. asperula* by its smooth branchlets. In addition, there are some differences in the pod and seed. The pod of *D. genistifolia* has a more sharply curved lower suture than the pod of *D. asperula* (cf. Figs 1 & 2). In *D. genistifolia* the seed is more oblong and more compressed than in *D. asperula* and the aril is only 1-lobed and is not so thick that it obviously projects beyond the profile of the seed (cf. Figs 1 & 2).

D. asperula and *D. genistifolia* are separated geographically, and are probably a vicariant species pair in the sense of Croizat, Nelson & Rosen (1974). *D. genistifolia* occurs principally in and near the Great Dividing Range from north-east Victoria, through New South Wales, to southern Queensland. A disjunct population of *D. genistifolia* is in the Flinders Ranges, South Australia, the closest occurrence of that species to *D. asperula* (Map 2). These plants in the Flinders Ranges are a particularly slender form of *D. genistifolia*, with straight terete phyllodes quite unlike the curved flat phyllodes of *D. asperula* on Eyre Peninsula (see subsp. *obliqua* below).

Plants resembling *D. asperula* and *D. genistifolia*, but differing from both in having phyllodes which are continuous with the branchlets, occur in the mallee districts of South Australia, Victoria and New South Wales. These plants belong to a new subspecies of *D. benthamii* (see below).

Plants of *D. asperula* with flattened phyllodes have been referred in some cases to *D. incrassata* Sm. and in others to *D. polyphylla* Benth. (Black, 1924 et auct.). Large inflated pods distinguish both the latter species, which are endemic in Western Australia, from *D. asperula*.

Variation

Variation in the phyllodes of *D. asperula* is great, ranging from subulate, subterete shapes to flat, obliquely obovate shapes. Subulate-leaved plants are mainly found on Kangaroo Island whereas flat-leaved plants are virtually restricted to Eyre Peninsula. A few intermediates occur on both Eyre Peninsula and Kangaroo Island. These morphologic-geographic populations are treated below as two subspecies. The boundary between these subspecies is somewhat arbitrary, because of the existence of intermediates, but the extremes are very different and the intermediates are few. The subspecies are so different in superficial appearance that previously (Black, 1924 et auct.) they have been referred to different species. Thus, the subulate-leaved forms were referred to *D. genistifolia* and the flat-leaved forms were referred to *D. incrassata* and *D. polyphylla*.

Key to Subspecies

Phyllodes subulate, broadest at or near base .... subsp. *asperula*

Phyllodes falcate or obliquely narrow-obovate, broadest at or above middle .... subsp. *obliqua*

subsp. asperula

D. incrassata sensu J.M. Black, Fl. S. Austral., 296 (1924); *ibid.* ed. 2, 435 (1948); *pro parte*, non Sm. *D. genistifolia* sensu J.M. Black, Fl. S. Austral., 296 (1924); *ibid.* ed. 2, 435 (1948); *pro parte*, non A. Cunn. ex Benth.

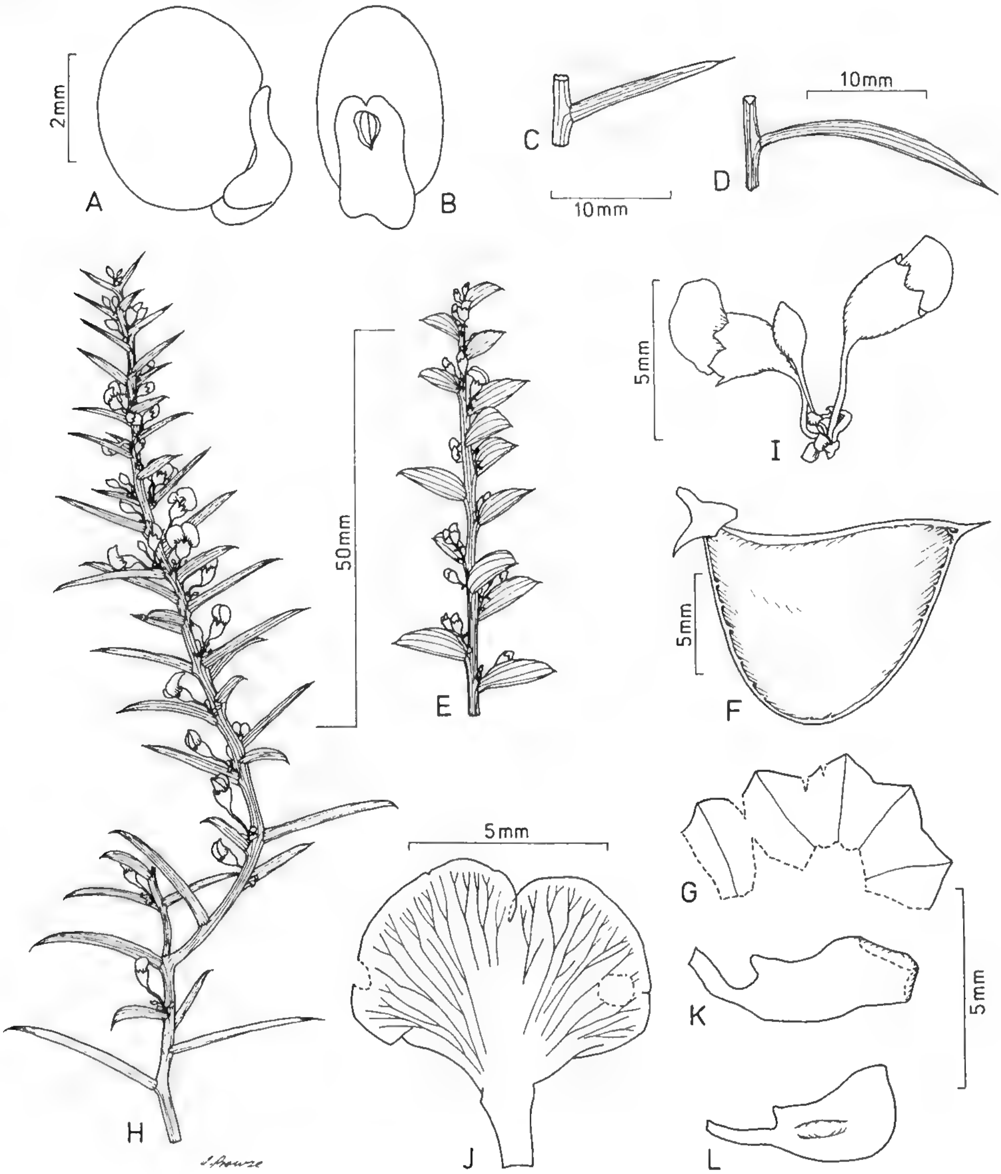


Fig. 1. *Daviesia asperula* Crisp. A-C, subsp. *asperula*. A-B, seed with aril; C, phyllode. D-G, subsp. *obliqua* Crisp. D, phyllode; E, habit; F, pod; G, calyx, opened out, upper lobes at left. H-L, intermediate between subspecies. H, habit; I, inflorescence; J, standard; K, wing; L, keel. Broken lines indicate overlap or damage. (A-B, *Choo 13*; C, *M.E Phillips s.n., Holotype*; D, *P.G. Wilson 357*; E & G, *Whibley 1994*; F, *Brown s.n.* (MEL 80939); H-L, *Donner 2094*). E, F, H & I drawn by A. Prowse.

Phyllodes subulate, compressed or subterete, recurved only near base, tapering from base to apex, 1-1.5 mm broad. (Fig. 1, A-C).

Distribution (Map 1).

Mainly Kangaroo Island, with one or two outliers on southern Eyre Peninsula, and a single record from Waitpinga, Fleurieu Peninsula.

Selected specimens

SOUTH AUSTRALIA: Kangaroo Island, near estuary of Harriet River, Vivonne Bay, *L.T. Choo 13*, 16.i.1970 (CBG); Fleurieu Peninsula, Waitpinga, *J.G. Fraser s.n.*, 18.x.1955 (AD 97622007); Kangaroo Island, Ropers Flat, between Aerodrome and Big Gums, *G. Jackson 73*, 9.x.1960 (AD); Kangaroo Island, 8.5 miles [13.6 km] from Emu Bay towards Stokes Bay, *M.E. Phillips s.n.*, 26.ix.1965 (AD, CBG 021590); Kangaroo Island, Kelly Hill Caves, 35° 58′ S, 136° 54′ E, *A.G. Spooner 6068*, 7.x.1978 (AD); Kangaroo Island, Dudley Peninsula, 0.5 km E of Cape Hart turn-off on Sapphiretown/Cape Willoughby road, 35° 50′ S, 138° 01′ E, *J.G. West 1263*, 22.xii.1975 (CBG); Eyre Peninsula, Warunda, *Herb. S.A. White s.n.*, 9.x.1909 (AD 97923312).

subsp. **obliqua** Crisp, subsp. nov.

D. polyphylla sensu J.M. Black, Fl. S. Austral., 296 (1924); *ibid.*, ed. 2, 435 (1948), non Benth.

A *D. asperula* subsp. *asperula* phyllodiis complanatis falcatis (lunatis) vel oblique angusto-obovatis versus medium vel supra latissimis (1.5-4.5 mm latis) versus basin contractis dignoscenda.

Type: South Australia, southern Eyre Peninsula, between Yalunda Flat and Tumby Bay, c. 20 km west of Tumby Bay, *D.J.E. Whibley 1944*, 26.viii.1967 (*holo*: AD).

The subspecific epithet refers to the oblique or unequal-sided phyllodes.

Phyllodes falcate (crescentic) or obliquely narrow-obovate, flattened, recurved along the entire length of the upper or both margins, broadest at or above the middle, contracted towards the base, 1.5-4.5 mm broad. (Fig. 1, D-G).

Distribution (Map 1).

Eyre Peninsula, mainly south of Yeelanna, but with an outlier between Cowell and Whyalla.

Selected specimens

SOUTH AUSTRALIA: Eyre Peninsula: Hundred of Wanilla, section 99, *C.R. Alcock C. 127*, 19.xii.1964 (AD); Hundred of Wanilla, section 100, *C.R. Alcock 915*, 16.viii.1965 (AD); Fishery Bay, Hundred of Sleaford, section 11, *C.R. Alcock 1627*, 17.ix.1967 (ADW); Yeelanna, 34° 09′ S, 135° 44′ E, *Anon (School) s.n.*, x.1937 (AD 97736536); Port Lincoln, *J.H. Brown s.n.*, 1873 (MEL 80939); c. 8 km E of Yallunda Flat, *B. Copley 3140*, 16.ix.1970 (AD); between Whyalla and Cowell, *M.E. Phillips 282*, 26.viii.1964 (CBG); Port Lincoln, [*C.*] *Wilhelmi s.n.*, sine die (MEL 80352); Warrow-Edilillie road, on North Block, Marble Range, 11 km E of Warrow, *P.G. Wilson 357*, 10.x.1958 (AD, K).

Relationship between subspecies

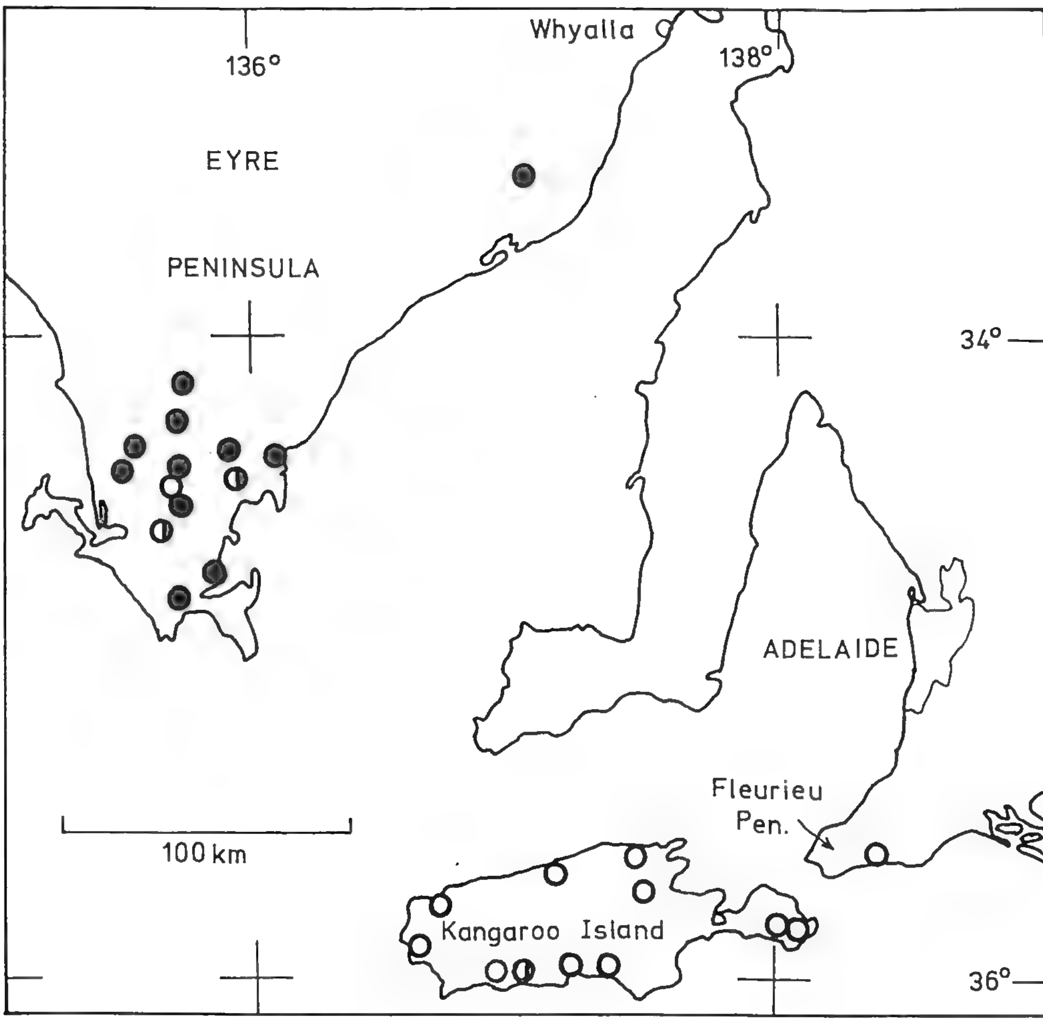
As indicated above, the circumscription of the two subspecies is somewhat arbitrary because of the existence of intermediates. However, there are relatively few intermediates (below and Map 1) compared with the large number of specimens typical of either population. Most specimens from Kangaroo Island have the typically compressed, subulate, straight phyllodes of subsp. *asperula*. In most specimens from Eyre Peninsula they are clearly flattened and falcate, at least along the upper margin, and are typical of subsp. *obliqua*.

It is curious that there are one or two specimens typical of subsp. *asperula* (e.g.

White s.n.) from Eyre Peninsula, when the obvious barrier separating vicarious groups within *D. asperula* is the 100 km stretch of sea between Eyre Peninsula and Kangaroo Island.

Intermediate specimens

SOUTH AUSTRALIA: Eyre Peninsula: c. 1 km S of Pearlah siding, *N.N. Donner 2094*, 26.viii.1967 (AD, CBG, K); a few miles N of Tod Reservoir, Koppio, *A.H. Freund s.n.*, 5.ix.1935 (AD 97701097). Kangaroo Island: Karatta, *Anon. s.n.*, 14.xi.1886 (AD 97622040); Hundred of Gosse, section 55, *G. Jackson 1002*, 8.ix.1974 (AD).



Map 1. Distribution of *Daviesia asperula* subsp. *asperula* (○), subsp. *obliqua* (●) and intermediates between subspecies (◑).

Daviesia benthamii Meissner subsp. **humilis** Crisp, subsp. nov.

D. genistifolia sensu Benth., Fl. Austral. 2: 82 (1864), *quoad spec. Dallachy*; J.M. Black, Fl. S. Austral., 296 (1924), *pro parte*; *ibid.*, ed. 2, 435 (1948), *pro parte*; non A. Cunn. ex Benth., *sensu stricto*.

A *D. benthamii* subsp. *benthamii* statura humiliore (ad 0.6 m alta) et phyllodiis numerosis ramulos praeter versus basin vestientibus differt.

Type: South Australia, Flinders Range, Wilpena Pound, just N of Sliding Rock in Pound Gap, 31° 33′ S, 138° 35′ E, *M.D. Crisp 931*, 22.x.1974 (*holo*: CBG; *iso*: K).

The subspecific epithet refers to the low-growing habit of the plants.

Dense, often depressed *shrubs* 0.3-0.6 m tall; branchlets usually clothed with phyllodes to near base, rarely naked up to half-way from base. *Phyllodes* continuous with branchlet, spreading or slightly ascending, terete, pungent, 5-30 mm long, 1-1.75 mm diameter at base, smooth. *Racemes* with 4-6 flowers, rhachis 2-7 mm long. *Flowers* small e.g. *standard* c. 5 x c. 5.5 mm. *Pod* rather small (5.5-7 x 4-5.5 mm) and slightly rounded in outline. (Fig. 3).

Distribution (Map 2).

D. benthamii subsp. *humilis* is scattered through the mallee districts of South Australia, Victoria and New South Wales, from Eyre Peninsula in the west to Wyalong in the east.

Selected specimens

SOUTH AUSTRALIA: Lower Eyre Peninsula, Lock, c. 140 km N of Port Lincoln, *J.B. Cleland s.n.*, 9.xi.1960 (AD 96803458); South East, roadside between Padthaway and Xmas Rocks, c. 35 km WSW of Bordertown, *D. Hunt 2147*, 19.ix.1964 (AD, CBG); 1.5 miles [2.4 km] N of McDonald Reserve, c. 3 miles [5 km] SE of Hartley, *R. & E.J. Melville 71.666*, 2.x.1971 (K); South East, Pine Hill, ENE of Bordertown, *R.D. Pearce 90*, 31.x.1976 (ADW, K); Kangaroo Island, Kingscote, *J.G.O. Tepper s.n.*, xi.1878 (AD 97622061 *p.p.*, MEL 80962).

VICTORIA: Whipstick Mallee Scrub, 18 miles [29 km] NNE of Bendigo, *E.F. Constable 5231*, 23.x.1964 (K, NSW); 0.5 miles [0.8 km] from Rushworth, *M.E. Phillips s.n.*, 29.xi.1961 (CBG 003665).

NEW SOUTH WALES: 10 miles [16 km] from West Wyalong to Rankins Springs, *J.W. Wrigley s.n.*, 15.xii.1971 (CBG 043516).

Habitat

D. benthamii subsp. *humilis* occurs in mallee districts, in slightly more humid areas than does subsp. *benthamii* in South Australia (Map 2). It is found on a variety of soils e.g. skeletal soil on mountain slopes, sandy loam over limestone, and gravelly clay. The vegetation of its habitat is typically mallee (dominated by shrubby *Eucalyptus* spp.) but is occasionally heath or woodland.

Affinity

This new taxon has been placed as a subspecies of *D. benthamii* because like that species, it has phyllodes which are continuous with the branchlets, calyx lobes which are apiculate, and flowers and pods of a similar shape and rather small size (standard up to c. 5.5 mm broad, pod up to 7 x 5.5 mm). Black's (1924) inclusion of it in *D. genistifolia* is not surprising because the habit and phyllodes are similar in these two taxa. However, *D. genistifolia* differs from both subspecies of *D. benthamii* by the articulation at the base of its phyllodes, but its larger flowers (e.g. standard more than 6 mm broad) and by its larger pods (more than 9 x 7.5 mm). In *D. genistifolia* the calyx lobes are not (or scarcely) apiculate, unlike the strongly apiculate calyx lobes of *D. benthamii*. The same

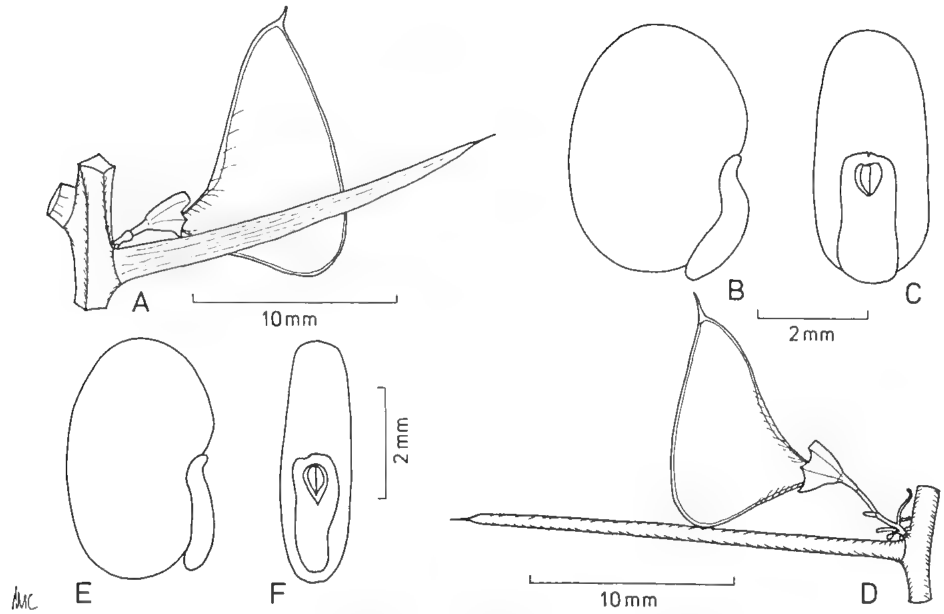


Fig. 2. *Daviesia genistifolia* A. Cunn. ex Benth. A, phyllode and pod; B-C, seed with aril; D, phyllode and pod; E-F, seed with aril. (A-C, *Carr 7195* [CBG]; D-F, *Shoobridge s.n.* [CBG 000864])

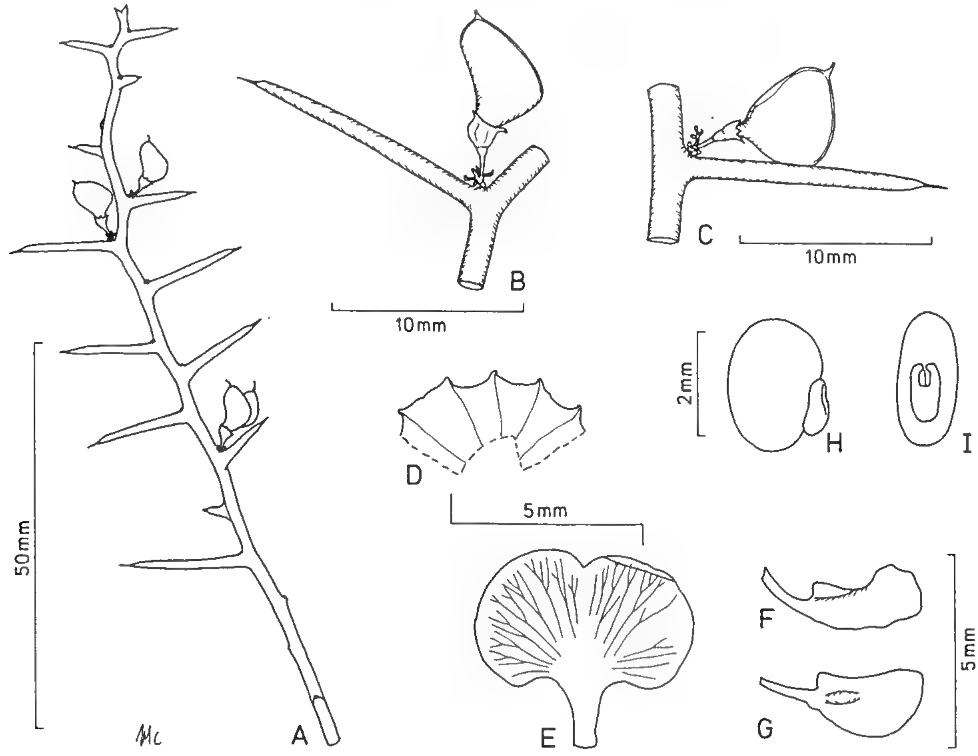
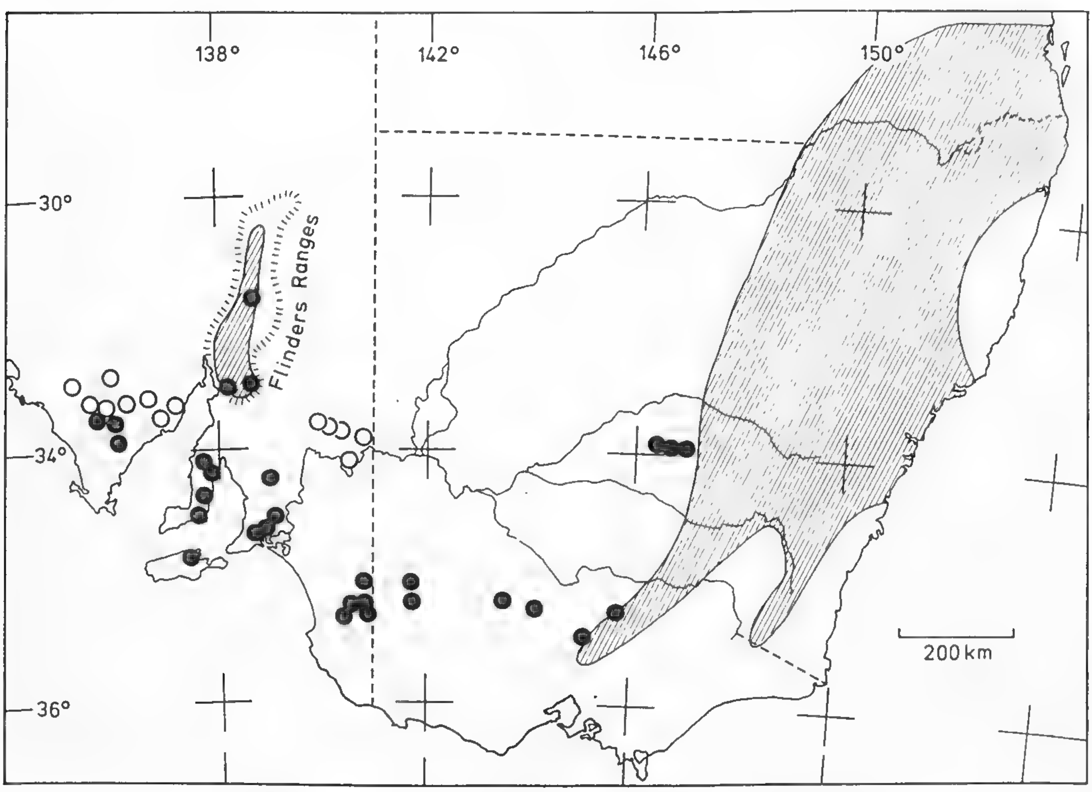


Fig. 3. *Daviesia benthamii* Meissner subsp. *humilis* Crisp. A, habit; B-C, phyllodes with pods; D, calyx opened, upper lobes at left; E, standard; F, wing; G, keel; H-I, seed with aril. Broken lines indicate cuts. (A-B, *Wrigley s.n.* [CBG 043516]; C, *Tepper s.n.* [MEL 80962]; D-G, *Crisp 931, Holotype*; H-I, *Tepper s.n.* [AD 97622061]).

character states distinguish *D. asperula* from *D. benthamii*. Where the distributions of *D. genistifolia* and *D. benthamii* subsp. *humilis* overlap (Map 2), there appear to be no intermediate plants.

In South Australia, *D. benthamii* subsp. *benthamii* (syn. *D. nudula* J.M. Black) differs markedly from subsp. *humilis* in having the phyllodes reduced to a few short stout spines at the branchlet apices and in its long, slender inflorescence rhachides and pedicels. *D. benthamii* subsp. *benthamii* occurs in drier localities in South Australia than does subsp. *humilis* (Map 2), but there is no evidence of a cline in phyllode size or number linking the two populations, nor are there intermediates of any kind. These taxa are so well distinguished in South Australia that if they were considered in that state alone, they could be treated as distinct species. However, as one proceeds westwards into Western Australia, subsp. *benthamii* grades from the extreme form described above into a form with longer, more numerous phyllodes and shorter inflorescence rhachides and pedicels. This latter form includes the type of the species, and occurs in the moister western parts of the wheatbelt of Western Australia. It is very similar to subsp. *humilis*, but there are slight differences. In the typical form of subsp. *benthamii* the phyllodes, although reasonably long and numerous, rarely extend further than one third of the way down each branchlet, and the habit is taller (to 1 m) and more open than in subsp. *humilis*. These slight differences, taken with the geographic separation, seem to justify separation of the typical form of *D. benthamii* and subsp. *humilis* at subspecies level.



Map 2. Distribution of *Daviesia benthamii* subsp. *humilis* (●). For comparison, partial distributions of *D. benthamii* subsp. *benthamii* (○), also in western South Australia and Western Australia; and *D. genistifolia* (shading), also in central Queensland.

It is possible that the two populations were once linked along the coastal plain which formerly existed in the Great Australian Bight south of the Nullarbor Plain. This corridor existed at times during the Pliocene-Pleistocene-Holocene (Nelson 1981), and provided an east-west migration route for species which today cannot tolerate the dry conditions and/or calcareous soils of the Nullarbor Plain.

Daviesia stricta Crisp, sp. nov.

Frutices ramulis anguste alatis, phyllodiis planis inermibus glaucescentibus, inflorescentiis umbellatis, lobis calycum aequalibus; *D. wyattianae* F.M. Bailey proxime cognata, sed calyce anguste campanulato viscido in fructu accrescente, lobis eiusdem acuminatis, pedicellis (2-5 mm) pedunculisque (3-7 mm) brevioribus differt.

Type: South Australia, Flinders Ranges district, Wilpena Pound, 2 km SE of St Mary's Peak, 31° 31′ S, 138° 34′ E, *M.D. Crisp 830*, 31.viii.1974 (*holo*: CBG; *iso*: to be sent to AD, BISH, K, L, MEL, NSW, PERTH, US).

The specific epithet is from the Latin *strictus*, meaning very upright or very straight, and refers to the branchlets and phyllodes, which are usually stiffly erect.

Open *shrub* to 1.5 m tall. *Branchlets* usually rigidly erect, compressed-triquetrous, narrowly winged, smooth. *Phyllodes* arranged spirally, erect or ascending, flat, narrow- to linear-elliptic, obtuse or acute, mucronate, articulate at base, 10-100 x 1.5-15 mm, with prominent midrib and obscure venation, coriaceous, glaucescent. *Inflorescence* umbelliform, (1-) 2 (-5) per axil, 3-5 flowered; rhachis 3-7 mm long. *Pedicels* slender, 2-5 mm long. *Calyx* narrow-campanulate, c. 5 mm long; lobes uniform, c. equal to tube, acuminate, recurved at the tips, with raised midribs, viscid, maroon, accrescent in fruit. *Corolla*: *standard* very broad-ovate, shallowly emarginate, c. 7.5 x 6.5 mm including the broad, 2.5 mm long claw, orange with purplish centre, fading yellow-brown; *wings* obovate, auriculate, purplish; *keel* half elliptic, slightly auriculate, saccate, purplish. *Stamens* free; anthers dimorphic. *Pod* narrow-triangular, acuminately beaked, enclosed at base by enlarged calyx, 9-13 x 5-7 mm. *Seed* compressed, reniform in outline, c. 4.5 x c. 2.5 mm; *aril* not seen. (Fig. 4).

Distribution (Map 3).

South Australia: Flinders Ranges.

Selected specimens

SOUTH AUSTRALIA: Flinders Ranges: Gammon Plateau, 7 miles [11 km] E of Arcoona Creek Camp. *C.W. Bonython, G.F. Gross & F.J. Mitchell s.n.*, 19.ix.1956 (AD 95735023); Bibliando Station, N boundary of West Bore Paddock, 31° 50′ S, 139° 03′ E, *M.D. Crisp 759*, 14.iv.1974 (CBG); Wilpena Pound, 2 km SE of St Mary's Peak 31° 31′ S, 138° 34′ E, *M.D. Crisp 829*, 31.viii.1974 (CBG, K); Wilpena Pound, by creek near Cooinda Camp, 31° 32′ S, 138° 33′ E, *M.D. Crisp 834*, 31.viii.1974 (AD, ADW, CBG); Bibliando Station, c. 50 km E of Hawker, summit of the Bluff, 31° 51′ S, 139° 00′ E, *M.D. Crisp 898 & 899*, 20.x.1974 (AD, BISH, BM, BRI, CBG, K, L, MEL, MO, NSW, NT, PERTH); Mt Hack, c. 50 km SE of Leigh Creek, *T.R.N. Lothian 5282 & 5283*, 9.ix.1973 (AD, NT).

Habitat

D. stricta occurs on ridge-tops and precipitous mountain slopes, apparently always on skeletal, quartzite-derived soils. The vegetation is shrubland, usually dominated by mallee *Eucalyptus*, with an understorey of heath-like shrubs or *Triodia*.

Affinity

D. stricta has only one very close relative, from the east coast of Australia,

D. wyattiana. Despite obvious similarities, these two species are readily separable by characters of the calyx, inflorescence and pod. In *D. wyattiana* the calyx is broadly campanulate, with the lobes narrow-acute but not acuminate and rarely recurved at the tips. It is neither viscid nor enlarged in fruit. The peduncles (7-28 mm) and pedicels (7-14 mm) are longer than in *D. stricta*. In *D. wyattiana*, the pod is slightly smaller and proportionally broader (8-10 x5-6 mm) than in *D. stricta*, and is not acuminate at the apex. Less reliably, these species can be separated by their phyllodes, which tend to be narrow-linear and longer (up to 200 mm) in *D. wyattiana*. However, specimens of *D. wyattiana* from the south coast of New South Wales and eastern Victoria have shorter, broader phyllodes which cannot be distinguished from those of *D. stricta*.

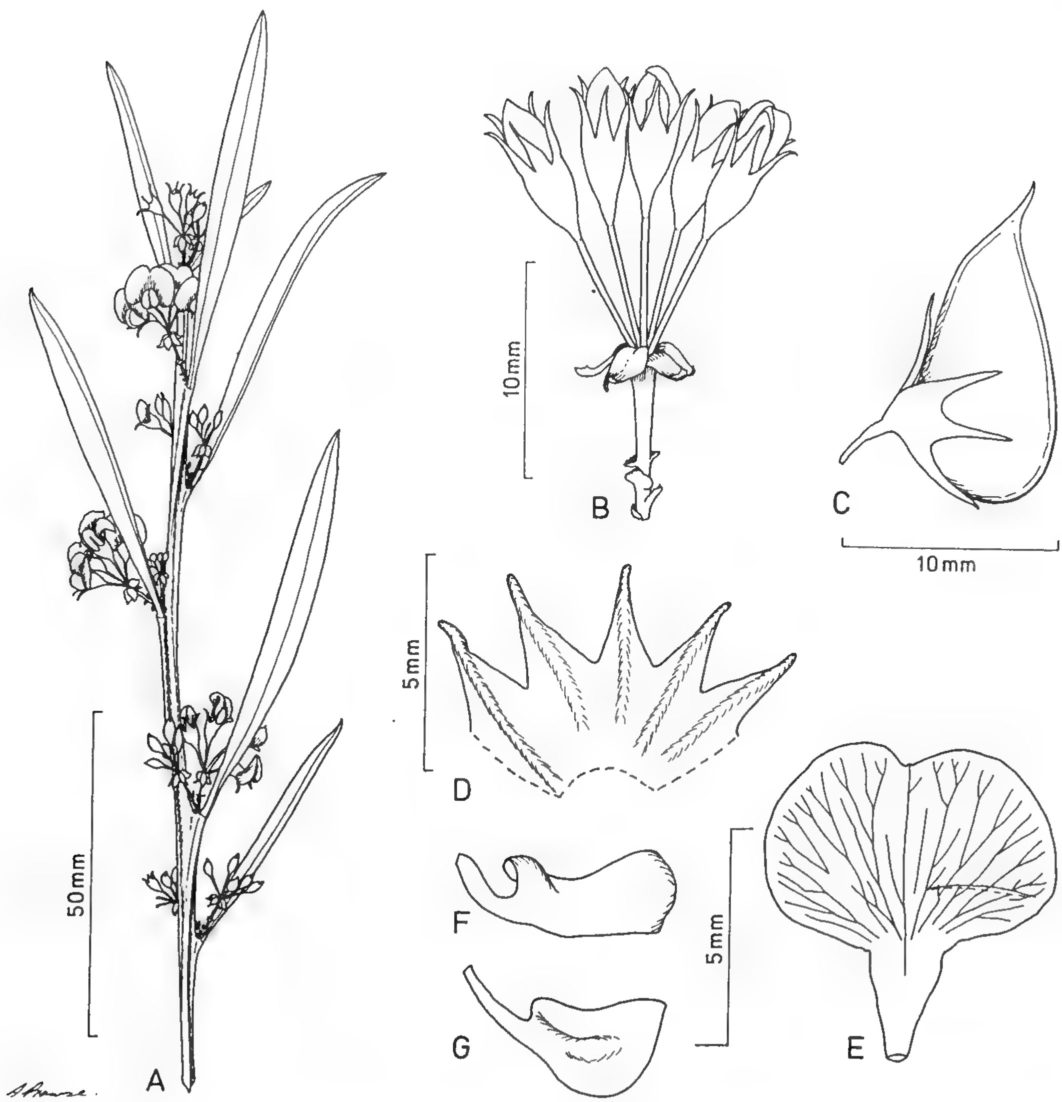
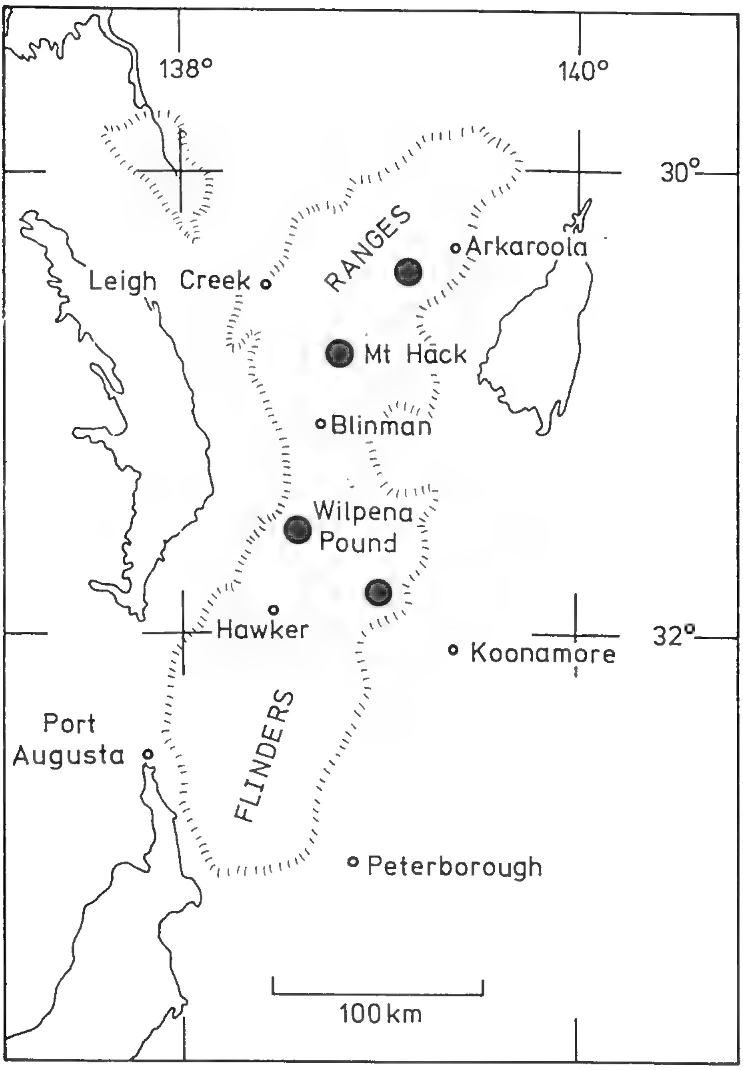


Fig. 4. *Daviesia stricta* Crisp. A, habit; B, inflorescence; C, pod with accrescent calyx; D, calyx opened out, upper lobes at left; E, standard; F, wing; G, keel. Broken lines indicate overlap or cuts. (A, *Crisp 829*; B-G, *Crisp 830, Holotype*). A-C drawn by A. Prowse.

In South Australia, the only other species of *Daviesia* with horizontally flattened, non pungent phyllodes is *D. mimosoides* R. Br. This species differs from *D. stricta* by its green, not glaucescent phyllodes, and by its racemose inflorescence.



Map. 3. Distribution of *Daviesia stricta*.

Pultenaea elachista (F. Muell.) Crisp, comb. nov.

Gastrolobium elachistum F. Muell., Fragm. Phytogr. Austral. 9: 67 (1875)—*Type*: 'In eremo interiore trans sinum Fowler's Bay; E. Giles' (MEL, *n.v.*).

Pultenaea cymbifolia J.M. Black, Trans. Proc. R. Soc. S. Austral. 39: 96, t. 10 (1915).—*Type*: 'Between Kingscote and Cassini, K.I., flowering May, 1914 (H.W. Andrew)' (*holo*: AD (*n.v.*); *iso*: K).

This species has all the essential characters of *Pultenaea*, and it is surprising that the new combination has not been made before. The leaves have typically scarious stipules which are shortly united at the base, sheathing the petiole. The phyllotaxis is decussate, and although this feature is not common in *Pultenaea*, it is seen in a few other species e.g. *P. arida* E. Pritzel, *P. obcordata* (R. Br.) Benth. and *R. rotundifolia* (Turcz.) Benth. The inflorescences are within the range described for the genus by Sands (1975, Fig. 1), with flowers solitary in the axils of upper leaves. These subtending leaves have slightly larger stipules and a more persistent indumentum than normal leaves. They correspond with the 'SL' bract category of Sands (1975, Fig. 2). The bracteoles are typical for the genus, being at the base of the hypanthium, large and persistent. Other characters consistent with *Pultenaea* are the two ovules per ovary and the aril on the seed. The stamens are quite free from each other and from the petals, excluding this species from the closely related genus *Phyllota*.

A note by C.A. Gardner on the isotype in K of the synonym *Pultenaea cymbifolia* states that the bracteoles are not persistent. Thus Gardner excludes *P. cymbifolia* from *Pultenaea* and places it under *Gastrolobium elachistum*. In fact, this specimen has persistent bracteoles, as do the other specimens I have seen. Perhaps Gardner later changed his mind, because an invalid new combination of *G. elachistum* under *Pultenaea* in Blackall & Grieve (1954) is attributed to him. Blackall and Grieve's combination is not validly published because there is no reference to the basionym.

Acknowledgements

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References

Black, J.M. (1924). "Flora of South Australia", part 2. (Govt. Printer: Adelaide).

Blackall, W.E. & Grieve, B.J. (1954). "How to know Western Australian wildflowers", part 2. (Univ. W. Austral. Press: Perth).

Croizat, L., Nelson, G. & Rosen, D.E. (1974). Centers of origin and related concepts. *Syst. Zool.* 23: 265-287.

Nelson, E.C. (1981). Phytogeography of southern Australia. In Keast, A. (ed.), "Ecological Biogeography of Australia", pp. 735-759. (W. Junk: The Hague).

Polhill, R.M. (1981). Tribe 25. Mirbelieae. In Polhill, R.M. & Raven, P.H. (eds.), "Advances in Legume Systematics", pp. 391-392. (Royal Botanic Gardens, Kew: London).

Sands, V.E. (1975). The cytoevolution of the Australian Papilionaceae. *Proc. Linn. Soc. N.S. Wales* 100: 118-155.

Stafleu, F.A. & Cowan, R.S. (1976). "Taxonomic literature", ed. 2, vol. 1. (Bohn, Scheltema & Holkema: Utrecht).

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A NEW SUBSPECIES OF *BRACHYLOMA ERICOIDES* (SCHLTDL.) SOND. (EPACRIDACEAE) FROM SOUTH AUSTRALIA

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Abstract

Brachyloma ericoides (Schltdl.) Sond. is neotypified. *B. ericoides* subsp. *bicolor*, subsp. nov., is described and illustrated from Kangaroo Island, South Australia and compared with subsp. *ericoides*.

Introduction

While visiting Kangaroo Island in October 1978 the author observed that the plants of *Brachyloma ericoides*, widespread and locally common on the island, were markedly distinct from the mainland form, particularly in flower colour. The contrasting pale green corolla tube and orange lobes of the insular plants make them easily distinguishable from the mainland plants with their uniformly pink flowers.

The existence of two forms had been recognised for some time (I. Jackson, pers. comm.). Eichler (1965) discussed the difference in flower colour and filament shape and suggested that two distinct taxa were involved but he wanted to investigate the problem further before describing them. Investigations by the present author have revealed further differences in leaf length and shape of flower (see Table 1) and all of these are the basis for the division of *B. ericoides* into two subspecies.

Brachyloma ericoides (Schltdl.) Sond., Linnaea 26: 247 (1853); F. Muell., Fragm. Phyt. Aust. 4: 98 (1864); F. Muell., Fragm. Phyt. Aust. 6: 39 (1868); Benth., Fl. Aust. 5: 172 (1870); Black, Fl. S. Aust. ed. 2 (3): 674 (1952); Eichler, Suppl. Black's Fl. S. Aust. 256 (1965); Jackson, Kangaroo Island Wildfl. (1975); Cochrane et al., Flowers & Plants Vict. t. 82, col. (1968); Willis, Handb. Pl. Vict. 2: 512 (1973).

Basionym: *Lobopogon ericoides* Schltdl., Linnaea 20: 620 (1847).

Type citation: "Auf kalkig-sandigem Boden, (sandplaine) bei Bethanien. August".

Type material: *H.H. Behr s.n.*, Bethany, South Australia. The holotype has been destroyed (Eichler, 1965 and pers. comm., 1981); a neotype is selected here from material collected from near the type locality, because no other type material could be located.

Neotypus: *R. Bates 958*, 27.v.1981, sandy scrubland 6 km south-west of Bethany (34° 34′ S 138° 50′ E) Barossa Valley, Southern Lofty region, South Australia (AD98126244) iso.: B, BM, CANB, GOET, K, MELB, NSW).

Description

Woody, perennial shrubs 20-90 cm high with sparsely pubescent branches. *Leaves* shortly petiolate, linear-lanceolate, (3-) 5-16 (-18) mm long, 1-2 mm broad, tapering into a fine, pungent mucro, flat or slightly convex above, glabrous except for sparsely ciliolate margins, paler and striated below. *Flowers*, solitary, axillary; stalk (peduncle and pedicel) 1-2 mm long; bracts and bracteoles 3-7, up to 3 mm long. *Sepals* 4 or 5, (2-) 3-4 (-5) mm long almost scarious like the bracteoles. *Corolla* 6-8 mm long, tubular, glabrous outside, much inflated at first then constricted below the 5 obtuse, imbricate

2-3 mm long lobes which are papillose and have a pad of fleshy tissue covered with reflexed hairs just below their base inside the corolla tube. *Filaments* fleshy 0.4-2.0 mm long, inserted at summit of tube; anthers obtuse, attached near the top and somewhat cohering to form a ring. *Ovary* 5-6 celled; style 2-3 mm long which is long for the genus; stigma 5 lobed. *Fruit* drupaceous; stone globular with 5 major ribs and 5 minor ribs/ridges between them, woody 3.5-5 mm in diameter.

Distribution and ecology

B. ericoides is distributed widely from the Barossa Valley in the Northern Lofty, through the Southern Lofty, Murray and South-East regions and on Kangaroo Island in South Australia. It occurs also in western Victoria and is uncommon in south-western New South Wales. It is generally encountered in light sandy forest or calcareous mallee.

Plants flower at any time during the year depending on rainfall. The main flowering period is from July to September or later in cooler, damper districts. Mature fruits and flowers are commonly found together on the same plant. Emus eat the fruits and the partial digestion of the woody seed capsule probably aids in germination of the seeds.

Notes

B. ericoides has close affinities with the Western Australian species *B. concolor* F. Muell. and *B. preissii* Sond. These three species make up Bentham's section *Lobopogon*, with coloured flowers subtended by several bracts, corolla tubes much inflated and with obtuse corolla lobes. The other species of *Brachyloma* which are restricted to the eastern States and South Australia have white flowers subtended only by two bracteoles, with hardly inflated corolla tubes and with corolla lobes acuminate. These constitute Bentham's section *Lissanthoides.*

Table 1. Characters by which *Brachyloma ericoides* subsp. *ericoides* and subsp. *bicolor* differ.

	subsp. ericoides	subsp. bicolor
Leaf length	5-12 mm	10-16 mm
Colour of corolla tube, bracteoles and sepals	pink	pale green
Colour of corolla lobes	pink to reddish	bright orange-yellow
Inflated base of corolla lobes	rounded	angular
Anther filaments	1.4-2 mm long, broad ovate to obovate, appressed inside corolla, easily seen below anthers.	< 1 mm long, narrow ovate, emerging at right angles to corolla, so short as to be hidden by anthers.

subsp. **ericoides**

Lobopogon ericoides Schltdl., Linnaea 20: 620 (1847).

Brachyloma ericoides (Schltdl.) Sond., Linnaea 26: 247 (1853).

Stenanthera ericoides (Schltdl.) F. Muell., Fragm. Phyt. Aust. 4: 98 (1864).

Cyathodes ericoides F. Muell., Fragm. Phyt. Aust. 4: 98 (1864) nom. nud.

Styphelia lobopogona F. Muell., Fragm. Phyt. Aust. 6: 39 (1868), nom. illeg.

Type: as for *L. ericoides* Schltdl.

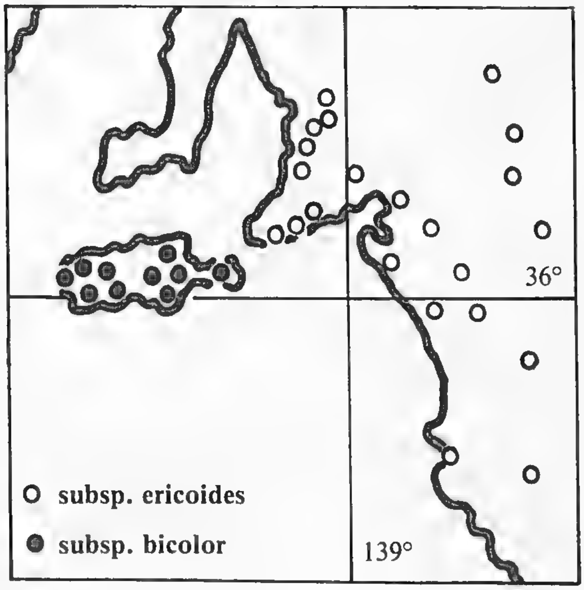
Compact shrubs 30-50 cm high or drawn up by surrounding vegetation into straggly shrubs to 90 cm. *Leaves* (3-) 5-12 (-14) mm long. *Flower* stalks 1-2 mm long; bracts 3-7. *Sepals* pink. *Corolla* 6-7 mm long; tube constricted immediately below the lobes and inflated from near the middle to the base, wholly pink; lobes 2.5-3.0 mm long, their bases rounded. *Filaments* 1.4-2.0 mm long, broad, ovate to obovate, appressed to the corolla and easily seen below the anthers in the dissected (fresh) flower; style c. 2.5 mm long.

This subspecies is restricted to the mainland, occurring from about Adelaide in the west, into western Victoria and the south-west of New South Wales, generally in sandy soil or with limestone. (Map 1).

Specimens examined at AD

VICTORIA: *A.C. Beauglehole 30837*, 25.iv.1969, Grampians; *A.C. Beauglehole 28745*, 1.x.1968, Wyperfield.

SOUTH AUSTRALIA: *H.M. Cooper s.n.*, May, 1941, Nangkita; *J.B. Cleland s.n.*, 8.xi.1958 Coorong; *Hj. Eichler 16378*, 14.xi.1959, Nuriootpa; *D. Hunt 2048*, 27.vi.1964, Kingston, S.E.; *E.H. Ising s.n.*, 16.viii.1957, Waitpinga; *D. Kraehenbuehl 302*, 21.v.1961, Milang; *M.C. Sharrad 7*, 8.viii.1959, Yumali; *A.G. Spooner 801*, 15.vi.1970, Billiat Conservation Park; *A.G. Spooner 1535*, 11.ix.1971, Monarto South; *B. Warren 16*, 17.v.1969, Peebinga in dunes; *R.M. Welbourne 179*, 31.v.1964, Hundred of Spence near Naracoorte, *D.J.E. Whibley 1415*, 7.vii.1964, Golden Grove; *P.G. Wilson 1938*, 24.viii.1961, near Keith.



Map 1. Distribution of *Brachyloma ericoides* in South Australia.

subsp. **bicolor** R. Bates, subsp. nov.

A subspecies typica foliis longioribus, tubo corollae bracteolisque pallide viridibus, lobis corollae laete aurantiacis, basibus inflatis acutius angulatis, filamentisque ovatis brevissimis et infra antheris differt.

Holotypus: *G. Jackson 1198*, 7.viii.1979, Kingscote Estate (35° 56′ S, 137° 52′ E) Kangaroo Island, South Australia (AD98153239), iso.: BM, CANB.

Shrubs 20-60 cm high, usually erect but occasionally procumbent in deeply shaded areas. *Leaves* (6-) 10-16 (-18) mm long. *Flower* stalks c. 1 mm long, bracts 4-6. *Sepals* pale green. *Corolla* 6-8 mm long; the tube constricted immediately below the lobes and inflated over 2/3 of the lower half, pale green and translucent; the lobes 2-3 mm long, with acute angle at their base, orange. *Filaments* less than 1 mm long, narrow, ovate, hidden by the anthers; style 2.5-3 mm long. (Fig. 1).

This subspecies appears restricted to Kangaroo Island where it is widespread in sandy soils or on limestone. I. Jackson (pers. comm. 1979) notes that the ripe fruits are edible and those of the typical subspecies were also found to be palatable. The fruits of the species are spherical when fresh but become more or less ridged when dry. (Map 1).

Specimens examined at AD

SOUTH AUSTRALIA: *R. Bates 472*, 9.viii.1978, Rocky River, Flinders Chase; *J.B. Cleland s.n.*, 26.ix.1964, Flinders Chase; *J.B. Cleland s.n.*, 27.x.1967, Cape de Couedic Road; *H.M. Cooper s.n.*, viii.1964, Pennington Bay; *Hj. Eichler 15494*, 14.xi.1958, Kelly Hill; *Hj. Eichler 15508*, 15.xi.1958, Flinders Chase; *E.H. Ising s.n.*, 30.xii.1922, MacGillivray; *G. Jackson 226*, 2.x.1962, Amen Corner; *G. Jackson 306*, 29.x.1963, Templetonia Reserve; *G. Jackson 617*, 15.vi.1969, Dudley Peninsula; *M.E. Phillips s.n.*, sub. CANB 01422, 30.viii.1964, D'Estree Bay (this specimen has the label '*B. halmaturinum* Eichl. m.s.' attached).

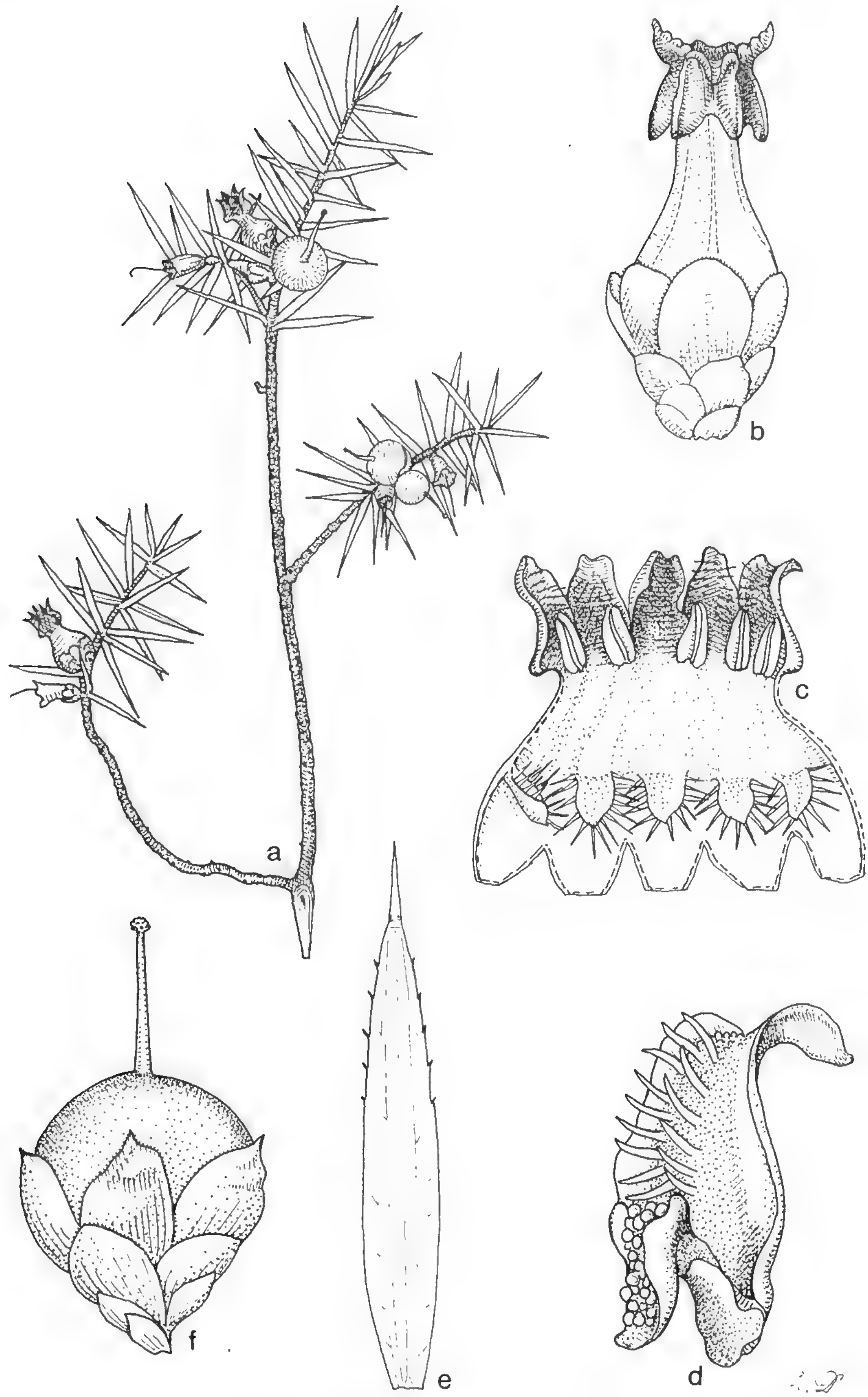


Fig. 1. *Brachyloma ericoides* subsp. *bicolor*, a, plant, X 2; b, flower, X 10; c, opened corolla showing inside, X 10; d, attachment of anther to corolla, X 45; e, leaf, X 6; f, fruit, X 12 (*I. Jackson 1198*, near Kingscote).

Acknowledgements

I am grateful to Ida Jackson (Mrs G. Jackson), who provided the material from which *B. ericoides* subsp. *bicolor* was illustrated and to the staff of the State Herbarium, Botanic Gardens, Adelaide, particularly Mr L. Dutkiewicz for preparing the illustration and Dr W. Barker for the Latin diagnosis. Dr Hj. Eichler, Canberra, A.C.T. suggested that *B. ericoides* be neotypified in this paper.

References

Bentham, G. (1870). "Flora Australiensis". Vol. 5. (Reeve: London).
Black, J.M. (1952). "Flora of South Australia" 2nd edn vol. 3 (Government Printer: Adelaide).
Cochrane, G.R., Fuhrer, B.A., Rotherham, E.R. and Willis, J.H. (1968). "Flowers and Plants of Victoria". (Reed: Sydney).
Eichler, Hj. (1965). "Supplement to J.M. Black's Flora of South Australia". (Government Printer: Adelaide).
Jackson, Ida (1975). "Kangaroo Island Wildflowers". (Islander Newspapers: Kingscote).
Mueller, F. (1864). "Fragmenta Phytographiae Australiae". Vol. 4. (Government Printer: Melbourne).
Mueller, F. (1868). ibid. Vol. 6. (Government Printer: Melbourne).
Schlechtendal, D. (1847). Bestimmung und Beschreibung der von Dr Behr in Süd-Australien gesammelten Pflanzen, *Linnaea* 20: 620.
Sonder, O.W. (1853). Plantae Muelleriana, *Linnaea* 26: 247.
Willis, J.H. (1972). "A Handbook to Plants in Victoria", Vol. 2. (Melbourne Univ. Press: Carlton).

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NOTES ON CASUARINACEAE II

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Abstract

Allocasuarina L. Johnson, gen. nov., is recognised as separate from *Casuarina sens. strict.* and 40 combinations at specific and subspecific level are made under the new genus. *Casuarina grandis* L. Johnson and *C. oligodon* L. Johnson are described together with a new subspecies, *C. oligodon* ssp. *abbreviata* L. Johnson, and *C. equisetifolia* ssp. *incana* (Benth.) L. Johnson, *stat. nov.* In *Gymnostoma*, combinations are made for 11 species.

This paper formally establishes the new genus *Allocasuarina*, together with new combinations for all those described taxa that will be recognised in the revision of Casuarinaceae at present being completed. Various new taxa will be described therein, but it is necessary to provide descriptions here for two species and a subspecies that will be treated in a booklet on uses of *Casuarina* and allied genera being prepared as a result of the International *Casuarina* Workshop held in Canberra in August, 1981.

The publication of *Allocasuarina* will permit use of this name in the forthcoming new edition of Flora of South Australia, Part II. Detailed discussion of generic and infrageneric relationships and distinctions within the family must await publication of the revision, as must distributional details, keys, illustrations, nomenclatural discussion, and listing of synonyms and collections.

The family comprises four genera: *Gymnostoma* L. Johnson (Johnson 1980), "genus C" to be described (confined to Malesia), *Casuarina* Adans. *s. str.*, and *Allocasuarina* L. Johnson. They are briefly discussed by Johnson and Wilson (1981), and our account of the family in Morley and Toelken (in press) gives a synopsis of the three genera native in Australia.

All types and isotypes cited have been examined in the herbaria named unless otherwise indicated.

ALLOCASUARINA L. Johnson

Allocasuarina L. Johnson, gen. nov.

Arbores vel frutices. Bracteolae infructescentiae plus minusve incrassatae protuberationibus dorsalibus saepe praeditae. Corpus samarae maturae castaneum vel fuscum vel nigrescens. Chromosomata maiora quam eis generis *Casuarinae*, x = 10, 11, 12, 13, 14.

Species typica: *A. torulosa* (Ait.) L. Johnson

Young persistent branchlets usually but not always distinguished from the deciduous branchlets; branchlets 4-13-ribbed, intercostal furrows deep, concealing the stomates as in *Casuarina*. Male flowers in simple short to long spikes, which in the flowering region are usually distinctly different from the vegetative branchlets. Female inflorescences as in *Casuarina*. Infructescences ("cones") borne amongst or below the assimilatory branchlets, pedunculate or sessile; bracts thin in the exposed portion, not vertically expanded; bracteoles considerably thickened and often divided so that the dorsal portion forms one or more distinct protuberances. Body of samara brown to black. Chromosomes x = 10, 11, 12, 13 or 14, larger than in *Casuarina*.

About 46 species, chiefly in the southern part of Australia but four species extending to NE. Queensland and one in tropical and subtropical parts of the eremaean region, usually on soils markedly deficient in nutrients.

The name is from Greek 'allos' = 'other', and *Casuarina*, which was first used by Rumphius (1743, p. 87) in allusion to the supposed resemblance of the "foliage" of *C. equisetifolia* to the plumage of the Cassowary, the name of the latter being latinised as *Casuarius*.

Allocasuarina acuaria (F. Muell.) L. Johnson, comb. nov.

Casuarina acuaria F. Muell., Fragm. 6: 16 (1867), basionym.

LECTOTYPE (here designated): Western Australia: in Australia occidentali, *Drummond 241* (MEL), ♀ infructescences. Isolectotypes: CAMB, K, LE, P.

Allocasuarina acutivalvis (F. Muell.) L. Johnson, comb. nov.

Casuarina acutivalvis F. Muell., Fragm. 10: 61 (1876), basionym.

HOLOTYPE: Western Australia: ad fontes Victoriae, *Young*, 30.ix.1875 (MEL), ♀ infructescence.

Allocasuarina acutivalvis ssp. **prinsepiana** (C. Andrews) L. Johnson, comb. et stat. nov.

Casuarina prinsepiana C. Andrews, J. West Aust. Nat. Hist. Soc. 1: 43 (1904), basionym.

HOLOTYPE: Western Australia: Mullewa, *C. Andrews*, vii.1903 (PERTH), ♀.

Allocasuarina campestris (Diels) L. Johnson, comb. nov.

Casuarina campestris Diels in Engler, Bot. Jahrb. 35: 126 (1905), basionym.

LECTOTYPE (Johnson 1972): Western Australia: Watheroo, *Diels 2038*, 31.xii.1900 (B), ♀ infructescences.

Allocasuarina campestris ssp. **eriochlamys** (L. Johnson) L. Johnson, comb. nov.

Casuarina campestris ssp. *eriochlamys* L. Johnson, Nuytsia 1: 264 (1972), basionym.

HOLOTYPE: Western Australia: Comet Vale, *J.T. Jutson 255*, viii.1917 (NSW), ♀.

Allocasuarina campestris ssp. **grossa** (L. Johnson) L. Johnson, comb. nov.

Casuarina campestris ssp. *grossa* L. Johnson, Nuytsia 1: 264 (1972), basionym.

HOLOTYPE: Western Australia: 5½ miles (9 km) N. of Norseman, *L. Johnson W177*, 18.xii.1960 (NSW), ♀ infructescences. Isotype: PERTH.

Allocasuarina corniculata (F. Muell.) L. Johnson, comb. nov.

Casuarina corniculata F. Muell., Fragm. 10: 62 (1876), basionym.

HOLOTYPE: Western Australia: prope montem Churchmanii, *Young*, 1875 (MEL), ♀ infructescences. Isotype: B.

Allocasuarina decaisneana (F. Muell.) L. Johnson, comb. nov.

Casuarina decaisneana F. Muell., Fragm. 1: 61 (1858), basionym.

HOLOTYPE: Western Australia: juxta Mount Mueller, *Mueller* (MEL—not found), ♀. Isotype: K (vegetative).

This is a distinctive species and readily recognised from vegetative material.

Allocasuarina decussata (Benth.) L. Johnson, comb. nov.

Casuarina decussata Benth., Fl. Austral. 6: 200 (1873), basionym.

HOLOTYPE: Western Australia: towards Cape Riche, *Drummond 5th coll. n. 434* (K), ♂, ♀ infructescences. (monoecious species). Isotypes: FI, LE, MEL.

Allocasuarina dielsiana (C.A. Gardner) L. Johnson, comb. nov.

Casuarina dielsiana C.A. Gardner, J. Roy. Soc. West. Australia 22: 119 (1936), basionym.

HOLOTYPE: Western Australia: summit of Mt. Singleton, *C.A. Gardner 2218*, 9.vii.1931 (PERTH), ♀ infructescences. Isotype: B.

Allocasuarina distyla (Vent.) L. Johnson, comb. nov.

Casuarina distyla Vent., Jard. Cels: 62, t. 62 (1800), basionym.

LECTOTYPE (here designated): presumably New South Wales (but recorded as "Cap de Diémen"), cult. Jardin de Cels, *herb. Ventenat* (G—not seen), ♀ infructescences. Isotypes: K, P; fragment NSW ex G.

The species represented by the type material does not occur in Tasmania, hence there must be an error in the locality recorded by Ventenat (Johnson in Curtis 1967).

Allocasuarina drummondiana (Miq.) L. Johnson, comb. nov.

Casuarina drummondiana Miq., Rev. Cas.: 26, t. I (1848), basionym.

HOLOTYPE: Western Australia: Swan River, *Drummond in Hb. Hook.* (K). Isotype: U.

Allocasuarina fibrosa (C.A. Gardner) L. Johnson, comb. nov.

Casuarina fibrosa C.A. Gardner, J. Roy. Soc. West. Australia 13: 61 (1928), basionym.

HOLOTYPE: Western Australia: in distr. Avon prope Tammin, *C.A. Gardner*, ix.1926 (PERTH), ♀ infructescences and inflorescence. Isotype: MEL.

Allocasuarina fraseriana (Miq.) L. Johnson, comb. nov.

Casuarina fraseriana Miq., Rev. Cas.: 59, t. VI D (1848), basionym.

LECTOTYPE (here designated): Western Australia: in arenosis sylvae circa oppidum Perth, *Preiss 2000*, 9.iv.1840 (U), ♀ infructescence. Isolectotypes: B, LE, MEL, W.

An amendment made to the International Code of Botanical Nomenclature at Sydney in 1981 requires the epithet in cases such as this to be spelled "*-eriana*", etc. Determinations made by me under earlier editions of the Code, as "*fraserana*", should thus be corrected.

Allocasuarina grevilleoides (Diels) L. Johnson, comb. nov.

Casuarina grevilleoides Diels in Engler, Bot. Jahrb. 35: 130 (1905), basionym.

HOLOTYPE: Western Australia: in distr. Avon ad Moore River in collium quos vocant Babilon Hills, *Diels 4019*, 30.viii.1901 (B), ♂, ♀ (monoecious).

Allocasuarina helmsii (Ewart & Gordon) L. Johnson, comb. nov.

Casuarina helmsii Ewart & Gordon, Proc. Roy. Soc. Victoria 32: 192 (1920), basionym.

LECTOTYPE (here designated): Western Australia: Gnarlbine, *Helms*, 12.xi.1891 (MEL), ♀ infructescences. Isolectotypes: K, LE, MEL.

Allocasuarina huegeliana (Miq.) L. Johnson, comb. nov.

Casuarina huegeliana Miq. in Lehm., Pl. Preiss. 1: 640 (1845), basionym.

LECTOTYPE (here designated): Western Australia: inter fragmenta rupium ad latus orientale montis Brown, distr. York, *Preiss 2006* p.p., 5.ix.1839 (U), ♂. Isolectotypes: BR, C, FI, K, L, LE, MEL, P, S. Lectoparatype: *Preiss 2006* p.p. (LE), ♀.

Miquel describes male and female material for *Preiss 2006* but only a male specimen could be found in U.

Allocasuarina humilis (Otto & Dietr.) L. Johnson, comb. nov.

Casuarina humilis Otto & Dietr., Allg. Gartenzeitung 9: 163 (1841); basionym.

HOLOTYPE: (presumably Western Australia): in Nova Hollandia,—(B), ♂, ♀ inflorescence (monoecious species).

It is endemic in south-western Australia.

Allocasuarina inophloia (F. Muell. & F.M. Bailey) L. Johnson, comb. nov.

Casuarina inophloia F. Muell. & F.M. Bailey, Chem. & Druggist Australas. Suppl. 4: 92 (1882), basionym.

LECTOTYPE (here designated): Queensland: no locality (MEL), sterile, with bark and with Mueller's manuscript description and a letter from Bailey (12.1881) to Mueller in which the cones are described. Possible syntypes: BRI, K, MEL.

Allocasuarina lehmanniana (Miq.) L. Johnson, comb. nov.

Casuarina lehmanniana Miq. in Lehm., Pl. Preiss. 1: 639 (1845), basionym.

LECTOTYPE (here designated): Western Australia: in solo sublimoso distr. Hay, *Preiss 2005*, 7.xi.1840 (U), ♀. Isolectotypes: LE, MEL.

Allocasuarina littoralis (Salisb.) L. Johnson, comb. nov.

Casuarina littoralis Salisb., Prodr.: 2 (1796), basionym.

HOLOTYPE: New South Wales: Botany Bay, *Banks & Solander* (BM). Isotypes: NSW, P.

Allocasuarina luehmannii (R.T. Baker) L. Johnson, comb. nov.

Casuarina luehmannii R.T. Baker, Proc. Linn. Soc. N.S.W. 24: (1900), basionym.

LECTOTYPE: To be designated in the revision in preparation; there will be no change in the application of the name. The syntypes are from New South Wales.

Allocasuarina microstachya (Miq.) L. Johnson, comb. nov.

Casuarina microstachya Miq. in Lehm., Pl. Preiss. 1: 642 (1845), basionym.

LECTOTYPE (here designated): Western Australia: in arenosis planitiei haud longe a praedio rustico Maddington distr. Perth, *Preiss 1999*, 2.xi.1839 (U), ♂. Isolectotypes: B, BR, L, MEL, P, PR, S.

Allocasuarina monilifera (L. Johnson) L. Johnson, comb. nov.

Casuarina monilifera L. Johnson in Curtis, Student's Fl. Tasmania 3: 651 (1967), basionym.

HOLOTYPE: Tasmania: Tasman Arch, Eaglehawk Neck, *L. Johnson NSW 62593*, 15.i.1949 (NSW), ♂. Isotype: HO.

Allocasuarina muelleriana (Miq.) L. Johnson, comb. nov.

Casuarina muelleriana Miq., Nederl. Kruidk. Arch. 4: 99 (1856), basionym.

HOLOTYPE: South Australia: in monte Torrens, Lofty Ranges, *F. Mueller* viii.1850 (U), ♀ infructescence. Isotype: MEL.

See note on orthography under *A. fraseriana*; similar considerations apply here.

Allocasuarina nana (Sieber ex Spreng.) L. Johnson, comb. nov.

Casuarina nana Sieber ex Spreng., Syst. 3: 804 (1826), basionym.

HOLOTYPE: (presumably New South Wales): Nova Hollandia, *Sieber 328* (B), ♂. Isotypes: BR, C, FI, K, L, LE, MEL, P, PR, S.

Sieber probably collected the type material in the Blue Mountains, or just possibly in the area of the Royal National Park.

Allocasuarina paludosa (Sieber ex Spreng.) L. Johnson, comb. nov.

Casuarina paludosa Sieber ex Spreng., Syst. 3: 803 (1826), basionym.

HOLOTYPE: (The locality would be in N.S.W.): Nova Hollandia, *Sieber 329* (B), ♂, ♀ (the species is generally monoecious). Isotypes: BR, C, FI, K, L, LE, MEL, PR.

Allocasuarina paradoxa (Macklin) L. Johnson, comb. nov.

Casuarina paradoxa Macklin, Kew Bull.: 150 (1931), basionym.

LECTOTYPE (Johnson in Curtis 1967): Victoria: Cheltenham, *Audas*, v.1925 (AD), ♀ infructescences. Isolectotype: K.

The type material is unlikely to have been collected by Macklin despite some apparent duplicates in various herbaria bearing her numbers. In her paper (Macklin, 1927, p. 275), she says "The material from which the above description and figures were taken was collected at Cheltenham, Victoria, and made available to me through the kindness of Messrs. Audas and Morris, of the National Herbarium of Melbourne".

Specimens of this species have largely been determined by me as "*C. pusilla* ssp. *robusta*" or "*C. pusilla* ssp. *misera*". Apart from a few collections from the southern Mount Lofty region of South Australia (Mount Compass, Myponga, Upper Hindmarsh Valley, Inman Hills) that are referable to *A. robusta* (q.v.), all such specimens belong to one or other of the forms of the variable *A. paradoxa*, and the specific determinations should be corrected. *Some* southern Mount Lofty material is indeed *A. paradoxa*. Distinctions will be given by Johnson & Wilson, Flora S. Austral., ed. 3. Part II.

Allocasuarina pinaster (C.A. Gardner) L. Johnson, comb. nov.

Casuarina pinaster C.A. Gardner, J. Roy. Soc. West. Australia 27: 166 (1941), basionym.

LECTOTYPE (here designated): Western Australia: Kukerin, *Gardner 1732* (PERTH—not seen but there is no doubt of its identity). Possible isolectotype: NSW.

Allocasuarina pusilla (Macklin) L. Johnson, comb. nov.

Casuarina pusilla Macklin, Trans. Roy. Soc. South Australia 51: 272 (1927), basionym.

LECTOTYPE (here designated): South Australia: Encounter Bay, *Macklin 020*, 1.vii.1927 (AD), ♀ infructescences. Isolectotypes: BRI, K, MEL, NSW.

Specimens of this species have largely been determined by me as "*C. pusilla* ssp. *pusilla*". These determinations should be corrected. For material determined under other supposed subspecies see the notes on *A. paradoxa* and *A. robusta*.

Allocasuarina ramosissima (C.A. Gardner) L. Johnson, comb. nov.

Casuarina ramosissima C.A. Gardner, J. Roy. Soc. West. Australia 47: 54 (1964), basionym.

HOLOTYPE: Western Australia: in distr. Avon prope Dandaragan, *Gardner 9013* (PERTH), ♀ infructescences—(not seen but there is no doubt of its identity).

Allocasuarina rigida (Miq.) L. Johnson, comb. nov.

Casuarina rigida Miq., Rev. Cas.: 61, t. VII D (1848), basionym.

LECTOTYPE (Johnson in Curtis 1967): Queensland: sinus Moreton, *Fraser 189*, (K) [actually from or near Mt Lindsay], ♀ infructescences. Isolectotype: U.

Allocasuarina robusta (Macklin) L. Johnson, comb. et stat. nov.

Casuarina paludosa var. *robusta* Macklin, Trans. Roy. Soc. South Australia 51: 271 (1927), basionym.

LECTOTYPE: South Australia: Upper Hindmarsh Valley, *Macklin 014*, 1.vii.1927 (AD), ♀ infructescences (but the species is monoecious). Isolectotypes: BRI, K, MEL, NSW.

Most specimens determined by me, and some of those determined earlier by Macklin, with the epithet "*robusta*" in various ranks and combinations (chiefly as "*C. pusilla* ssp. *robusta*") in fact belong to *A. paradoxa*, q.v. *A. robusta* is very restricted.

Allocasuarina scleroclada (L. Johnson) L. Johnson, comb. nov.

Casuarina scleroclada L. Johnson, Nuytsia 1: 261 (1972), basionym.

HOLOTYPE: Western Australia: c. 40 km SSE. of Caiguna (c. 3.2 km in from sea), *L. Johnson 2155*, 1.ix.1967 (NSW), ♀ infructescences. Isotype: PERTH.

Allocasuarina striata (Macklin) L. Johnson, comb. nov.

Casuarina striata Macklin, Trans. Roy. Soc. South Australia 51: 267 (1927), basionym.

LECTOTYPE (here designated): South Australia: Belair, *Macklin 036*, 18.viii.1927 (AD), ♀. Isolectotypes: BRI, K, MEL, NSW.

Allocasuarina tessellata (C.A. Gardner) L. Johnson, comb. nov.

Casuarina tessellata C.A. Gardner, J. Roy. Soc. West. Australia 22: 119 (1936), basionym.

HOLOTYPE: Western Australia: summit of Mt Singleton, *C.A. Gardner 2217*, 9.viii.1931 (PERTH), ♀ infructescences. Isotypes: B, K.

Specimens of this were formerly determined by me as a subspecies of *C. campestris*. It is now clear that *A. tessellata* is best treated as a species, and determinations should be corrected accordingly.

Allocasuarina thuyoides (Miq.) L. Johnson, comb. nov.

Casuarina thuyoides Miq. in Lehm., Pl. Preiss. 1: 641 (1845), basionym.

LECTOTYPE (here designated): Western Australia: in planitie arenosa Quangen, distr. Victoria et in planitie arenosa prima eis fl. Gordon, distr. Hay, *Preiss 2004*, 20.iii.1840 and 7.xi.1840 (U), ♂ (impossible to separate localities and dates; on same sheet as ♀ specimen).

Allocasuarina torulosa (Ait.) L. Johnson, comb. nov.

Casuarina torulosa Ait., Hort. Kew ed. 1, 3: 320 (1789), basionym.

NEOTYPE: Queensland: Bay of Inlets, *Banks & Solander*, 1770 (BM), ♀ infructescences. Isoneotypes: MEL, NSW.

Miquel (1848) reported that Aiton's specimens had been lost. Aiton indicated Banks' collections as the source; his specimens were presumably from cultivated plants. The neotype collection also includes ♂ material, to be regarded as paraneotype.

Allocasuarina trichodon (Miq.) L. Johnson, comb. nov.

Casuarina trichodon Miq. in Lehm., Pl. Preiss. 1: 641 (1845), basionym.

HOLOTYPE: Western Australia: in saxosis ad latera collium Konkoberup, distr. Kent, *Preiss 2001*, 19.xi.1840 (U), ♂. Isotypes: L, LE, MEL, NSW, P.

Allocasuarina verticillata (Lam.) L. Johnson, comb. nov.

Casuarina verticillata Lam., Encycl. 2: 501 (1788), basionym.

LECTOTYPE: cult. Jardin du Roi (probably collected in Tasmania), *herb. Lamarck* (P-LA, photograph seen), vegetative; with a note attached giving manuscript description of male spikes (? in herb. Thouin—not now to be found in Montpellier), which corresponds in a number of distinctive phrases with Lamarck's published description.

C. stricta Ait., Hort. Kew ed. 1, 3: 320 (1789), synon. nov.

Determinations by me as *C. stricta* should be corrected. There is no doubt of the identity of the type material or of the application of the protologue. The epithet *verticillata* evidently refers to the tendency for semi-juvenile shoots to bear strongly radiating whorls of branchlets, as evident in the type material. The epithet *stricta*, though well known in recent years for this species, was formerly applied to various members of the *distyla* group, and is far from apt for the Drooping She-oak. Thus, the unavoidable change is perhaps more bearable than it would otherwise be.

CASUARINA Adans.

Casuarina equisetifolia Forst. & Forst. f. ssp. **incana** (Benth.) L. Johnson, stat. nov.

C. equisetifolia var. *incana* Benth., Fl. Austr. 6: 197 (1873), basionym.

LECTOTYPE (here designated): New South Wales: Port Macquarie, *A. Cunningham* $\frac{45}{\text{May 1819}}$ (K).

Casuarina grandis L. Johnson, sp. nov.

Arbor usque and 50-60 m alta, dioica; ramuli patentes vel subpenduli; articuli plerumque 6-11 mm longi, c. 0.4 mm diametro; phyllichnia angulata, angulis plus manifestis quam eis *C. cunninghamianae* sed minus acutis quam eis *C. oligodontis*; sulci sine pilis protrudentibus; laminae foliorum (dentes) 8-10, 3 mm longae, deltoideae, basi brunnei sed apice pallide marcescentes; spicae masculae ignotae; infructescentiae in pedunculis 6-10 mm longis, 14-18-stichae, globoso-cylindricae utrinque truncatae, 6-11 mm longae, 9-11 mm diametro, bracteolis fructiferis glabris brunneisque parte protrudenti 1.5-2.0 mm longa, 1.0-2.0 mm lata.

HOLOTYPUS: Papua New Guinea: Northern District: Tufi subd.: Mafo Barracks (on Ibinamo River), *P. Darbyshire 1156*, 19.vii.1963 (NSW), ♀. Isotypi: CANB, K.

Tree to 50-60 m tall, dioecious; branches spreading or ± pendulous; articles mostly 6-11 mm long, c. 0.4 mm diam.; phyllichnia angular, the angles more prominent than in *C. cunninghamiana* but less acute than in *C. oligodon*; furrows with protruding hairs; leaf-laminae ("teeth") 8-10, 3 mm long, deltoid, with a dark brown base, the apex

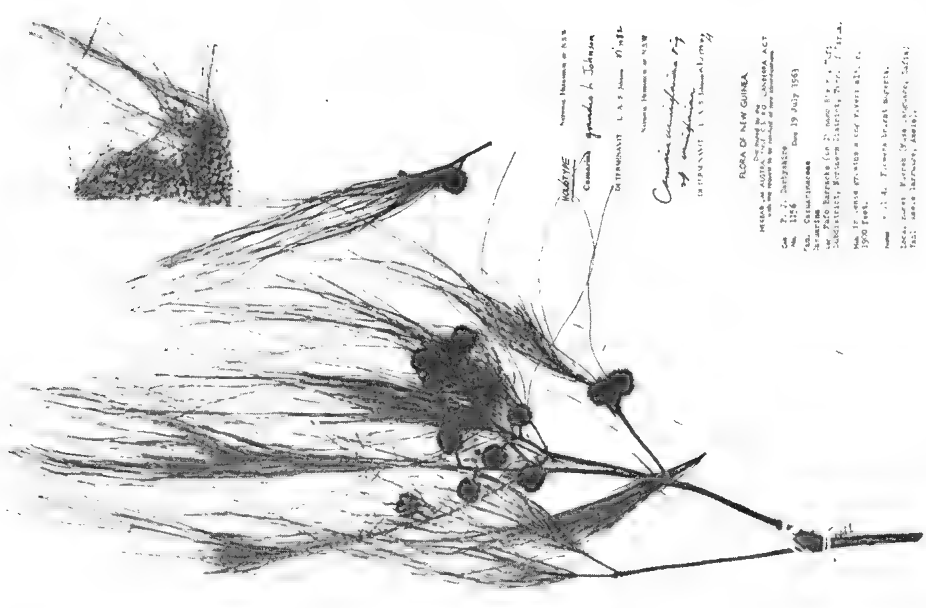


Fig. 1. Holotype of *Casuarina grandis* L. Johnson (*Darbyshire 1156*: NSW).

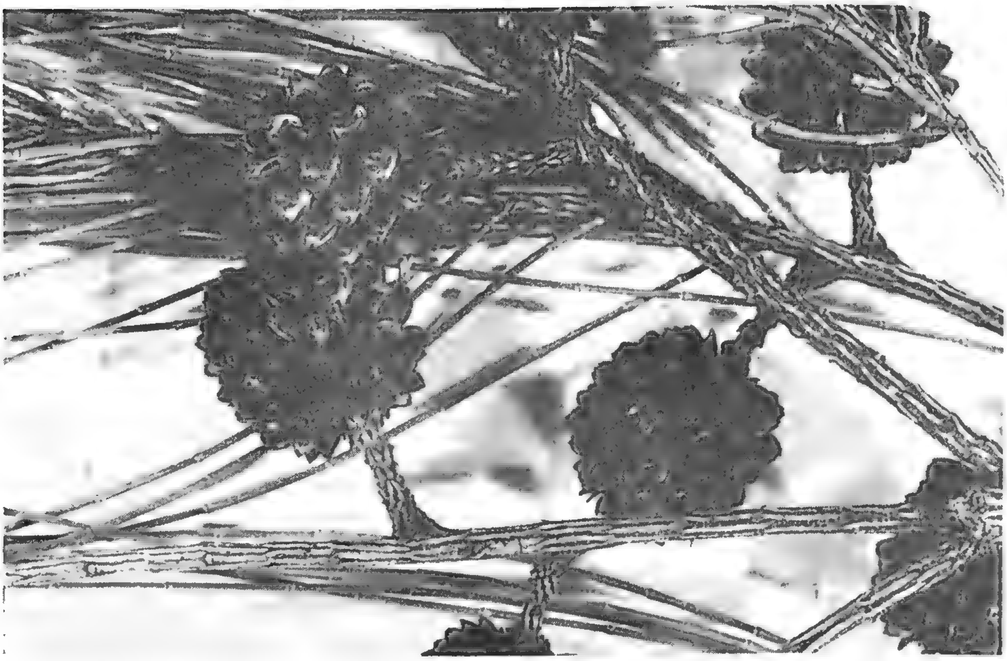


Fig. 2. Cones of *C. grandis* (from holotype).

withering pale; male spikes unknown; infructescences ("cones") on peduncles 6-10 mm long, 14-18-stichous, globose-cylindrical with both ends truncate, 6-11 mm long, 9-11 mm diam.; fruiting bracteoles glabrous, brown, with the protruding portion 1.5-2.0 mm long, 1.0-2.0 mm broad.

Known only from the south-eastern end of Papua from near Tufi in the Northern District to the Gwariu River in the Milne Bay District. The species is not recorded at more than 600 m altitude. It forms dense stands along rivers, regenerating on gravel banks and other open sites, possibly partly from root suckers as in *C. cunninghamiana*. It may also occur in small gullies eroded from volcanic debris. The trees appear frequently to attain heights of 35-40 m but there is one record (*Brass 23791*) of a height of 50-60 m. As a tall, fast-growing tropical species, *C. grandis* is considered to have economic potential in other parts of the world. In view of its close relationship to other species and the general lack of barriers to hybridisation within *Casuarina s. str.*, *C. grandis* is also likely to hybridise freely if grown with other species of *Casuarina s. str.*, with consequent difficulties of identification of progeny.

C. grandis is closely related to *C. cunninghamiana*, which is restricted to Australia, and also to an undescribed species from the Timor region, previously included in *C. junghuhniana*. Collections have been misdetermined, by myself as well as others, as *C. cunninghamiana* or *C. oligodon*. The differences between the species in this complex will be dealt with elsewhere.

Casuarina oligodon L. Johnson, sp. nov.

Arbor usque ad 30 m alta; dioica vel rarissime monoica; ramuli penduli; articuli 4-7 mm longi, 0.5-0.8 mm diametro; phyllichnia acutangula; sulci non vel vix pilosa; laminae foliorum (dentes) 5-7 acutae pallide marcescentes; spicae masculae 1.5-4.5 cm longae, plerumque in ramulis terminales vel rare subsessiles, verticillis circa 12-20 per cm; flores masculae bracteolis persistentibus, tepalis cucullatis glabriusculis, antheris rotundatis 0.5-0.6 mm longis; infructescentiae in pedunculis 0.5-1.0 cm longis, plerumque 12-stichae, breviter cylindricae vel subcylindricae, 4-10 mm longae, 0.7-0.9 mm diametro, bracteolis fructiferis glabratis parte protrudenti 1.5-2.0 mm longa, c. 1.5 mm lata.

HOLOTYPUS: Papua New Guinea: Eastern Highlands: Goroka subd.: Bena River, near Goroka, *J.S. Womersley NGF 24983*, 14.viii.1967 (NSW), ♂. Isotypi: BISH, BRI (also sent to A, BO, CANB, K, L, PNH, SING, US).

Tree to 30 m tall; dioecious or very rarely monoecious; branchlets pendulous; articles 4-7 mm long, 0.5-0.8 mm diam.; phyllichnia sharply angled; furrows not or scarcely hairy; leaves ("teeth") 5-7, acute, withering pale; male spikes 1.5-4.5 cm long, usually on terminal branchlets or rarely subsessile, with c. 12-20 whorls per cm; male flowers: bracteoles persistent, tepals hooded and becoming glabrous, anthers round, 0.5-0.6 mm long; infructescences ("cones") on peduncles 5-10 mm long, usually 12-stichous, shortly cylindrical or subcylindrical, 4-10 mm long, 0.7-0.9 mm diam.; the fruiting bracteoles glabrous, the protruding portion 1.5-2.0 mm long, c. 1.5 mm broad.

Representative ♀ specimen: PAPUA NEW GUINEA: Western Highlands: Laiagam subd.: near Kepilam village, Lagaip valley, *R. Hoogland & R. Schodde 7250*, 30.vii.1960 (K, LAE, NSW, UC).

The name is derived from Greek 'oligos' = 'few' and 'odon' = 'a tooth', since the teeth (leaves) on the branchlets are fewer than in *C. equisetifolia* Forst. & Forst. f. and the type race of *C. cunninghamiana* Miq., with which the species was first compared.

This New Guinea endemic is most closely related to two undescribed species, which are endemic respectively in Sulawesi (Celebes) and the island of Luzon in the Philippines.

Fig. 3. Holotype of *C. oligodon* L. Johnson (*Womersley NGF 24983*: NSW).

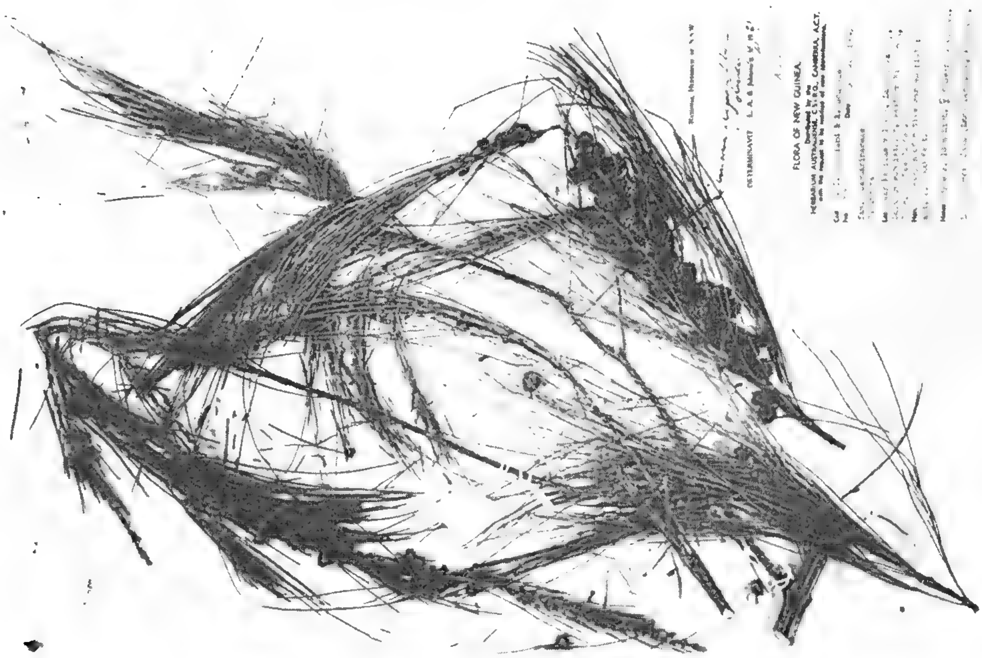


Fig. 4. Representative female specimen of *C. oligodon* ssp. *oligodon*.

It is close also to *C. cunninghamiana*, *C. grandis*, *C. junghuhniana* Miq. and an undescribed species from Timor and neighbouring islands. The distinctions from all these will be dealt with in the revision.

The species is well-known in New Guinea but in earlier times was often confused with *C. equisetifolia*, which is strictly coastal on the island. It has also been confused with *C. grandis*, q.v.

Two subspecies are readily distinguished.

a. ssp. **oligodon**

Leaves (teeth) long-acuminate, 0.8-1.0 mm long when undamaged.

East New Guinea (i.e. Papua New Guinea) in highland areas, chiefly on river banks but often planted near native gardens. It occurs chiefly between 1500 m and 2500 m altitude, but is recorded from as low as 250 m along the Ramu River. From near Aiyura in the Eastern Highlands, and from the Finisterre Range in the Madang District, extending at least as far west as the upper Strickland River.

b. ssp. **abbreviata** L. Johnson, ssp. nov.

Laminae (dentes) acute triangulares, 0.4-0.5 mm longae.

HOLOTYPUS: West New Guinea (Irian Jaya): Wissel Lake region, *Eyma 4541*, 12.ii.1939 (L), ♀. Isotypi: A, BO, CANB, K, L, LAE, NSW.

Highland areas of West New Guinea, from the Bele and Upper Balim Valleys at least as far west as the Wissel Lake region. As well as the markedly shorter teeth, to which the subspecific epithet refers, this subspecies tends to have shorter, more crowded whorls of male flowers, probably shorter anthers, and somewhat smaller infructescences than the eastern (type) race. I have seen many specimens, none of which are intermediate, but the differences are not great and subspecific rank seems sufficient.

GYMNOSTOMA L. Johnson

Gymnostoma chamaecyparis (Poiss.) L. Johnson, comb. nov.

Casuarina chamaecyparis Poiss., Nouv. Arch. Mus. Hist. Nat., ser. 1, 10: 108 (1874), basionym.

LECTOTYPE (here designated): New Caledonia: Mont Poume, *Balansa 3315*, v.1871 (P), ♀ infructescences.

There is also a sheet bearing the same number with ♂ flowering material; since the species is dioecious, this is excluded from the lectotype, though it is conspecific.

Gymnostoma deplancheanum (Miq.) L. Johnson, comb. nov.

Casuarina deplancheana Miq. in Candolle, Prodr. 16 II: 342 (1868), basionym.

HOLOTYPE: New Caledonia, *Deplanche 113* (L), ♀ infructescences. Probable isotypes: A, K, P, UPS.

There are specimens labelled *Deplanche 113* in all the herbaria cited, most of which are ♂ and bear infructescences and agree with the holotype. However, there was some admixture under this number and there are pieces in FI (♀) and UPS (vegetative) that belong to *G. poissonianum* and *G. glaucescens* respectively.

Gymnostoma glaucescens (Schlechter) L. Johnson, comb. nov.

Casuarina glaucescens Schlechter, Bot. Jahrb. Syst. 40, Beiblatt 92: 21 (1908), basionym.

HOLOTYPE: New Caledonia: Süd-Bezirk: Pouéta, *Le Rat 738*, vii.1903 (B) ♂. Isotypes: ? P, ? NSW.

Gymnostoma intermedium (Poiss.) L. Johnson, comb. et stat. nov.

Casuarina deplancheana Miq. γ [var.] *intermedia* Poiss., Nouv. Arch. Mus. Hist. Nat., sér. 1, 10: 50 (1874), basionym.

HOLOTYPE: "Forêts couronnant le mont Mi," *Balansa 1166*, 9.iii.1869 (P) ♀ infructescences. Isotype ?: NSW.

Gymnostoma leucodon (Poiss.) L. Johnson, comb. nov.

Casuarina leucodon Poiss., Nouv. Arch. Mus. Hist. Nat., ser. 1, 10: 107, t. VII (1874), basionym.

HOLOTYPE: New Caledonia: Collines ferrugineuses à l'ouest de Messioncoué près le Port Bouquet, *Balansa 2180*, 1868-70 (P), ♀ infructescences.

Gymnostoma nobile (Whitmore) L. Johnson, comb. nov.

Casuarina nobilis Whitmore, Tropical Rainforests of the Far East: 134 (1975), basionym.

HOLOTYPE: Sabah (N. Borneo): Sepitang Forest District: Seungau, *A. Cuadra A3292* (K), ♀ with mature infructescences. Isotypes: A, L, NSW, US.

This species was distinguished by myself, and many specimens were determined as *Gymnostoma nobile*. Whitmore (1975) adopted the epithet without acknowledgement and published the species, without my agreement, under *Casuarina*, using a type of his own choosing, and with a description that is quite undiagnostic, taken in isolation. Under the I.C.B.N., I have no choice but to take the binomial *G. nobile* as formally based upon *C. nobilis* Whitmore, with the citation as given above. Previous determinations in various herbaria do not, of course, give any parenthetical author's name. This may be added, if thought appropriate.

The characters that in fact distinguish *G. nobile* will be detailed in my revision, wherein it will be treated as the sole species of a series. It has been compared with *G. sumatranum*, from which it is readily distinguished by the thicker branchlets, generally smaller cones (infructescences) and lack of longitudinal striation on the infructescence bracts and bracteoles.

It forms a tree up to 20 m or more in height, although often smaller, with a fairly broad crown. It is commonly found in "heath-forest" at low altitudes (see, e.g., Whitmore 1975) on soils poor in nutrients, but also occurs on hills on various substrates, including limestone, up to 1400 m altitude. There are many collections from Borneo, where I have seen it on leached sands and peat.

A collection from the Cyclops Mountains in western New Guinea (Irian Jaya), formerly thought to belong to this species, proves to represent a new species of the series containing *G. sumatranum*. It will be described in the revision of the family. Determinations should be corrected accordingly.

Gymnostoma papuanum (S. Moore) L. Johnson, comb. nov.

Casuarina papuana S. Moore, J. Bot. 61, Suppl.: 53 (1923), basionym.

HOLOTYPE: Papua New Guinea: Sogeri region: South Cape, *H.O. Forbes 913a*, 1885-6 (BM), ♀ infructescence. Isotype: LE.

Gymnostoma poissonianum (Schlechter) L. Johnson, comb. nov.

Casuarina poissoniana Schlechter, Bot. Jahrb. Syst. 39: 91 (1907), basionym.

HOLOTYPE: New Caledonia: Süd-Bezirk: auf den Hügeln am Ngoye, *Schlechter 15144*, 29.xi.1902 (B), ♀ immature infructescences. Isotypes: BO, BR, K, NSW, S.

C. deplancheana Miq. var. *debilis* Poiss., Nouv. Arch. Mus. Paris, sér. 1, 10: 106 (1874).

LECTOTYPE (here designated): New Caledonia: Kanala, *Vieillard 1269*, 1861-67 (P), ♀ infl. and immature infructescences.

Schlechter referred to *C. poissoniana* as "n. sp." in the protologue and on the specimen labels, but stated that "sie identisch ist mit der von Poisson als *C. Deplancheana* Miq. var. *debilis* bezeichneten Pflanze". It seems reasonable to accept the sole collection cited as the holotype (with duplicates as isotypes), but if the view were taken that the material on which the species was based included the citation of Poisson's variety, then the Schlechter collection should be taken as lectotype, since it forms the main basis of his description as a "new species". There is no doubt of the specific identity of the elements concerned, so the matter is of little consequence.

Gymnostoma rumphianum (Miq.) L. Johnson, comb. nov.

Casuarina rumphiana Miq., Flora 48: 23, 38 (1865), basionym.

LECTOTYPE (here designated): Amboina [Ambon], *de Vriese s.n.* (L 899. 173-99). Possible isotypes: B, BO, BR, K, LE, P, S.

The *Synopsis specierum Casuarinae* of Miquel (1865) was clearly written as a single paper, but was published in two successive issues of the journal *Flora*: No. 2 (25 Jan. 1865) and No. 3 (4 Feb. 1865), in both of which there is reference to *C. rumphiana*.

On p. 18 (January) under the entry "18. C. Rumphiana Miq. n. sp.", there is a diagnosis followed by the reference: "C. montana Rumph. Herb. Amb. III. p. 87. tab. 58. excl. fig. A—Satis bona, sed ramuli nimis regulariter dispositi, et strobili haud exacta delineati. Cf. Rev. [i.e. Miquel 1848, L.J.] p. 16, ubi ad C. nodifloram provisorie retuli." and the distributional note: "Amboina, remotius a mari, in montibus et planitiebus."

In so far as this was all that was "associated with [the] name at its first publication" (Stafleu et al. 1978, footnote to Recommendation 7B), it would constitute the protologue, and one might at first suppose that the reference to Rumphius's [pre-Linnaean] description and figure should be taken as indicating the holotype under Art. 7.3: "A *holotype* is the one specimen or other element used by the author . . . ", and Art. 9.3: "if . . . a name is without a type specimen, the type may be a description or figure". However, Miquel's diagnosis includes observations (especially dimensions) that could not have been derived from the figure (very poor) and text in the *Herbarium Amboinense* of Rumphius (1743). That Miquel in fact *used* (cf. Art. 7.3) other material in drawing up his diagnosis is confirmed by the further treatment on page 38 (February) where, under "Adnotationes", he expresses satisfaction that the species described and delineated by "the immortal Rumphius" had been found again in Amboina by Teysmann and de Vriese, who had brought back fruiting specimens, of which he then proceeds to provide further detailed description. He refers also on p. 38 to a sterile specimen (which I have seen) collected earlier by Reinwardt, but neither this nor the figure or description of Rumphius could have been the source of Miquel's description on p. 24 of the *bracts* (as distinct from the bracteoles) of the infructescences. Thus, he must have had the Teysmann and de Vriese material available when drawing up the brief description in the first part of the paper.

In this paper in general, Miquel cited only *references* in the main enumeration (which ran over both dates of publication), reserving the citation of *specimens* for the "annotations", of which the further treatment of *C. rumphiana* on page 38 was one.

Thus, although by the accident of split publication it might be technically considered not to be part of the protologue, the text on page 38 provides information on the original material *used* by the author in drawing up the protologue. According to 4b of the "Guide for the Determination of Types" (Stafleu et al. 1978) "other things being equal, a specimen should be given preference over pre-Linnaean or other cited descriptions or illustrations when lectotypes . . . are designated, providing that the choice is in accordance with Rec. 7B" [i.e. preserves current usage]. In the present case, there is no doubt that all the elements (except possibly the vegetative specimen of Reinwardt) used by Miquel as the basis of his *C. rumphiana* are of the same species, and from the same small island. Consequently, I have chosen as lectotype one amongst the several specimens that were collected on Ambon by Teysmann and de Vriese jointly or separately.

The Leiden sheet cited was seen by Miquel.

The infructescence designated as "A" in the Rumphius plate cited belongs to *G. sumatranum*.

Gymnostoma sumatranum (Jungh. ex de Vriese) L. Johnson, comb. nov.

Casuarina sumatrana Jungh. ex de Vriese, Tijdschr. Natuur. Gesch. Physiol. 11: 115 (1844), basionym.

HOLOTYPE: In planitie alta Silantom et Tobah (3-4000′ [feet]), *Junghuhn* (L), ♀ infructescences. Isotype: U.

Gymnostoma webbianum (Miq.) L. Johnson, comb. nov.

Casuarina webbiana Miq., Flora 48: 33, 38 (1865), basionym.

LECTOTYPE (here designated): New Caledonia, *Labillardière* (ex herb. Webb) (K), vegetative; ♀ infructescence figured by Miquel apparently lost. Isolectotypes: FI, ♀ infructescence; BR, P, ♀ inflorescence.

"*C. nodiflora* var. *robustior dentibus obtusis*" Miq., Rev. Cas.: 17, t. IB (1848) (as "var. robustior" under the figure).

HOLOTYPE: as lectotype of *C. webbiana*, above, but cited as "Austro-Caledonia, sp. fem. (Webb, in Herb. Hook.)".

"*C. nodiflora* [var.]*β robusta* Miq." in Candolle, Prodr. 16 II: 342 (1868). This refers to "Miq. Rev. l.c." and can therefore be taken as an error for or variant of the earlier form with the epithet "*robustior*". The legitimacy of these varietal names may be arguable, but is of little consequence when the taxon is treated in specific rank.

Miquel (1865, pp. 33, 38) based his *C. webbiana* on two elements: (1) a reference to his earlier *C. nodiflora* var. *robustior* . . . . . . , (2) specimens collected in Borneo by de Vriese. The former element is here chosen as lectotype, the latter (one "de Vriese, Borneo", vegetative specimen in L) is referable to *G. nobile*.

As pointed out when describing *Gymnostoma* (Johnson 1980), the name *Casuarina nodiflora* has been widely misapplied to species throughout the range of *Gymnostoma*. In New Caledonia, beginning with Poisson (1874), it has been generally applied to the present species, and the true *G. nodiflorum* (Thunb.) L. Johnson has been known under the later synonym *Casuarina angulata* Poiss. Collections determined by A. Guillaumin, and not subsequently seen by myself, may have continued to bear such wrong names, and their determinations should be corrected.

Acknowledgements

Mrs Karen Wilson has worked closely with me in recent years on this study; I thank her for assistance in many ways. Thanks are due to the Directors and Curators of the many herbaria in which relevant material has been studied or from which loans have been made. These will be fully enumerated when the revision of the family is published. Dr J.F. Veldkamp, Rijksherbarium, Leiden, and Dr L.Y. Th. Westra, Utrecht, very kindly re-examined several sheets for me in relation to lectotypification.

References

Curtis, W.M. (1967). "The Student's Flora of Tasmania", vol. 3 (Govt Printer: Tasmania).

Johnson, L.A.S. (1972). New species and subspecies of *Casuarina* in Western Australia. *Nuytsia* 1: 261-265.

Johnson, L.A.S. (1980). Notes on Casuarinaceae. *Telopea* 2: 83-84.

Johnson, L.A.S., & Wilson, K.L. (1981). Casuarinaceae, then and now. XIII International Botanical Congress Abstracts: 278.

Johnson, L.A.S., & Wilson, K.L. (in production). Casuarinaceae. In Jessop, J.P. (ed.), "Flora of South Australia" ed. 3, Vol. 2. (Govt. Printer: Adelaide).

Miquel, F.A.G. (1848). Revisio critica Casuarinarum. *Nieuwe Verh. Eerste Kl. Kon. Ned. Inst. Wetensch. Amsterdam*, ser. 2, 13: 267-350, i.xii.

Miquel, F.A.G. (1865). Synopsis specierum Casuarinae. *Flora* 48: 17-24, 33-39.

Morley, B., & Toelken, H. (eds.) (in press). "Flowering Plants in Australia". (Rigby: Adelaide).

Poisson, J. (1874). Recherches sur les Casuarines et en particulier seur ceux de la Nouvelle Calédonie. *Nouv. Arch. Mus. Hist. Nat.*, ser. 1, 10: 59-111, pl. IV-VII.

Rumphius, G.E. (1743). "Herbarium Amboinense", Vol. 3. (Meinard Uytwerf: Amsterdam).

Stafleu, F.A., et al. (eds.) (1978). International Code of Botanical Nomenclature. *Regnum Veg.* 97.

Whitmore, T.C. (1975). "Tropical rain forests of the Far East". (Clarendon Press: Oxford).

J. Adelaide Bot. Gard. 6(1): 89-92 (1982)

BOOK REVIEWS

Acacias of Australia

Simmons, M. 'Acacias of Australia', 1982, Nelson.

Acacia is one of the largest and most widespread genera of Australian plants. 'Acacias of Australia' came to fruition after many years of planning with extensive travel throughout Australia, collecting, photographing and sketching in an effort by the author to make this complex genus more accessible to botanists, laymen and growers.

A special feature of this book is a section devoted to an overview of the genus *Acacia* written by Les Pedley, Assistant Director, Queensland Herbarium, who specialises in the taxonomy of *Acacia*.

One hundred and fifty species are treated individually. The text is adequate and clearly set out and no obvious errors were noted. For each species the scientific name with authority is given, together with common name where one exists, and the meaning of the scientific name is explained. The botanical description with a minimum use of technical terms is given under the sub-headings: distribution (statewide), habit, foliage, flowers, pods, seeds. Notes on special identification features and comments on propagation and cultivation seem useful.

Each species is illustrated by black and white drawings that are both artistic and informative. However, a little more emphasis showing enlarged finer details of some important identification features such as veins (position and numbers), or glands, would greatly assist the user.

The text is supported by 54 excellent colour photographs by John Simmons; these are informative and varied, showing habit and close-up details. Plate 49 is titled *Acacia rivalis*, but the correct identification should be *A. calamifolia*. Cross-referencing of photographs and descriptions would have been an added advantage. The chapter on propagation will interest and assist the grower. A short glossary with a page of illustrations explaining the major characteristics of *Acacia* appears to cover technical terms used.

A simple key to groups is included. This is satisfactory and serves the purpose to group plants with similar characteristics. It is a pity such a fine work did not include a key to all species.

The work includes a section on the naming of plants, which explains and lists the full names and dates of authors pertaining to the species included. The extensive bibliography is invaluable to the reader to stimulate further reading and gain information on *Acacia*. The book concludes with an index to the scientific and common names.

The title appears rather ambiguous with only 150 species treated (approx. 700 species are known to occur in Australia) and perhaps this could have been avoided by adding the word 'some' or the inclusion of an additional list of the remaining *Acacia* species grouped together with similar characteristics for each State. We hope Marion Simmons will continue the work and cover a wider range of species at a later date.

"Acacias of Australia' is visually attractive, beautifully produced and a clearly set out publication. It is obvious that a great deal of care, time and effort was spent and the author and publisher are to be congratulated on the result.

Simmons, Marion H. 1982. 'Acacias of Australia', pp. 325, figures 150, colour plates 54. (Published by T. Nelson, Melbourne). Hard-bound. $29.95.

David J.E. Whibley
State Herbarium of South Australia

'Native trees and shrubs of south eastern Australia'

Costermans, L., (1981), Rigby.

This excellent book, which embraces an area stretching from the Flinders and Mt Lofty Ranges in South Australia, across Victoria and southern New South Wales to the N.S.W. south coast, describes approximately 900 species of plant.

The book sets out to "interpret for popular usage, much of the accumulated scientific data and findings relevant to the larger plants in the area". This I believe it does very well. All indigenous species of trees and shrubs taller than 1 metre are treated; also included are some species which have become naturalised and are often mistakenly thought to be native e.g. *Coprosma repens* from New Zealand, *Olea europaea* introduced from Europe, and *Chrysanthemoides monilifera* introduced from South Africa.

In Chapter 2, 'The Land and its Vegetation', an excellent and concise description is given of the importance of geological and climatic factors on the formation of vegetation. Costermans wisely restricts himself to a few comments about the origin and distribution of the Australian flora, and his statements on succession and ecosystem development are easily read and informative. For further information the reader is referred to selected literature on the various topics covered.

In Chapter 3, 'Some Places of Special Interest', nine specific localities including the Grampians and Wilsons Promontory in Victoria are briefly dealt with, giving information of both an historical and ecological nature. As is evident elsewhere in the book photography is excellent and whets the reader's appetite for further investigation.

In Chapter 4 the region is divided into what Costermans calls "ecological—geographical areas", comprising eight in all. Although botanical keys are omitted the excellent line drawings are clear and accurate, making identification of the species in question fairly certain.

At this point the user is referred to a full description of the species in Chapter 5. These descriptions vary from a minimum of approximately 50 words to more than 200 depending on species and variation within the taxon. Excellent line drawings together with a distribution map complete the description.

Chapter 6 presents a few comments on the major families and genera mentioned in the book. These comments form a useful adjunct to the text itself and would make interesting reading for any enthusiastic amateur botanist. The book is completed by a short but comprehensive glossary, a list of abbreviations used in the book and two indices, one botanical, the other of common names.

Only a few criticisms can be levelled at this otherwise excellent work. Costermans uses an estimate of 14,000 species in Australia while most workers today would place this figure somewhere between 17,000 and 20,000. Some readers may take issue with the statement on p. 14 referring to the use of fire by the aborigines: "The Aborigines apparently brought about little change. They did burn the bush periodically to regenerate undergrowth but fire is a natural part of ecological processes. Essentially the Aborigines survival depended on living in harmony with Nature".

Leaving aside these two small criticisms I believe that the aim of the author, to make the book useful at any time of the year, not only during flowering periods, and to be self-explanatory in the hands of anyone, with or without training, prepared to devote effort to following up field observations, is achieved. The photography throughout, both colour and black and white, is excellent and the line drawings extremely accurate. This volume will form a useful reference tool in any library and can be readily recommended.

Costermans, L. (1981). 'Native Trees and Shrubs of South Eastern Australia,' pp. 422, more than 300 colour photographs and 160 in black and white line drawings. (Published by Rigby, Adelaide). Hard-bound, $29.95.

E.J. McAlister
Adelaide Botanic Gardens

Two books on the flora of New South Wales

Cunningham, G.M. et al. 'Plants of western New South Wales', 1982, N.S.W. Government Printer.
Jacobs, S.W.L. & Pickard, J. 'Plants of New South Wales', 1981, N.S.W. Government Printer.

The latest of the floras to deal with at least a part of New South Wales is a most impressive volume by G.M. Cunningham, W.E. Mulham, P.L. Milthorpe and J.H. Leigh. Aimed "particularly at the landholders" of western New South Wales it is more popular in approach than most floras, but will be welcomed by others including many professional botanists. Of particular value will be the outstanding colour photographs of the great majority of the approximately 2,000 vascular plant species included. Exceptionally informative notes, especially of an ecological nature, were made possible by the authors' considerable first hand field knowledge. The opportunities to include such notes are too rarely available to writers of floras, although most would appreciate the value in having them.

The presentation and printing are very good, but I find it difficult to refer from the text of a species to its associated photograph. This is partly because only the vernacular name is used as a caption, partly because it is printed in small lower case—very different from the large bold capitals used in the headings to the text—and partly because it is sometimes above and sometimes below the plate.

Reflecting to some extent its differences in emphasis from most other floras, several technical decisions in the book will not find favour with many botanists. As the authors predicted in their introduction many users will, for example, regret the absence of keys. The apparent fabrication and "standardisation" of "common names" will also be criticised (as occurred when J.H. Willis adopted the Victorian Naturalists vernacular names in his 'Handbook'), as will the use of lower case for their initial letters, even when used as captions. For example, "paterson's curse" will look strange to many. In writing descriptions for the lay public, terminology is a major problem. However, who has the courage and knowledge to tackle descriptions of details of grass inflorescences yet prefers to use the word "seeds" for lemmas, "husks" for glumes or "flowers" for spikelets? Numerous alternative "common names" are recorded but users attempting to look up species by botanical names other than those adopted in the book will fail to find any scientific synonyms.

In their introduction the authors emphasise the part played by S.W.L. Jacobs and J. Pickard's checklist of the plants of New South Wales. They used it as a guide to what species are naturalised, to the "form of presentation" of authors of plant names and to distribution outside their own area. Both works are dated 1981 (although the "Plants of western N.S.W.' did not actually appear until 1982) and the reader might be excused for assuming that the names adopted would also have been checked against the checklist. This was unfortunately, at least in part, not the case. Perhaps the most serious omission which use of the checklist could have avoided, was the failure to change *Bassia* (of which 30 species are described in the flora) to *Sclerolaena* or *Dissocarpus*, a change widely

accepted since A.J. Scott's publication of 1978. It could also have avoided adoption of the unpublished combination *Bulbinopsis alata* for a species validly published in *Bulbine* by H. Baijnath, in which genus most recent authors have agreed to place the taxon.

The checklist 'Plants of New South Wales' is also, in its own way, a lavish publication, perhaps in this case excessively so. This is the first comprehensive record of the seed plants of New South Wales in 65 years and, as such, fills a need felt, not only by workers in that State, but by others especially those involved in the floras of adjoining areas. The occurrence of each taxon (approximately 6,000 species) on Lord Howe Island and in 13 mainland N.S.W. regions is recorded. Although the occurrence of species in other States and overseas is also indicated, this information is, as the authors indicate, "not necessarily definitive". In fact a check of South Australian monocotyledons, for which a reasonable list was available to the authors, suggests that it is so bad as to have been better omitted.

Additional information is limited to whether or not the taxon is native (indicated not only for the State as a whole but also for each of the 14 regions) and the inclusion of a substantial number of synonyms. The families, genera and species recognised are arranged alphabetically, and the index is, therefore, justifiably restricted to family and generic names whether adopted or as synonyms. It is not stated on which system the family concepts are based. Perhaps some freedom was allowed the 15 contributors in the groups for which they were responsible.

Except for the interstate distribution data this is, in so far as I have been able to check, a very reliable and valuable addition to the literature on the Australian flora.

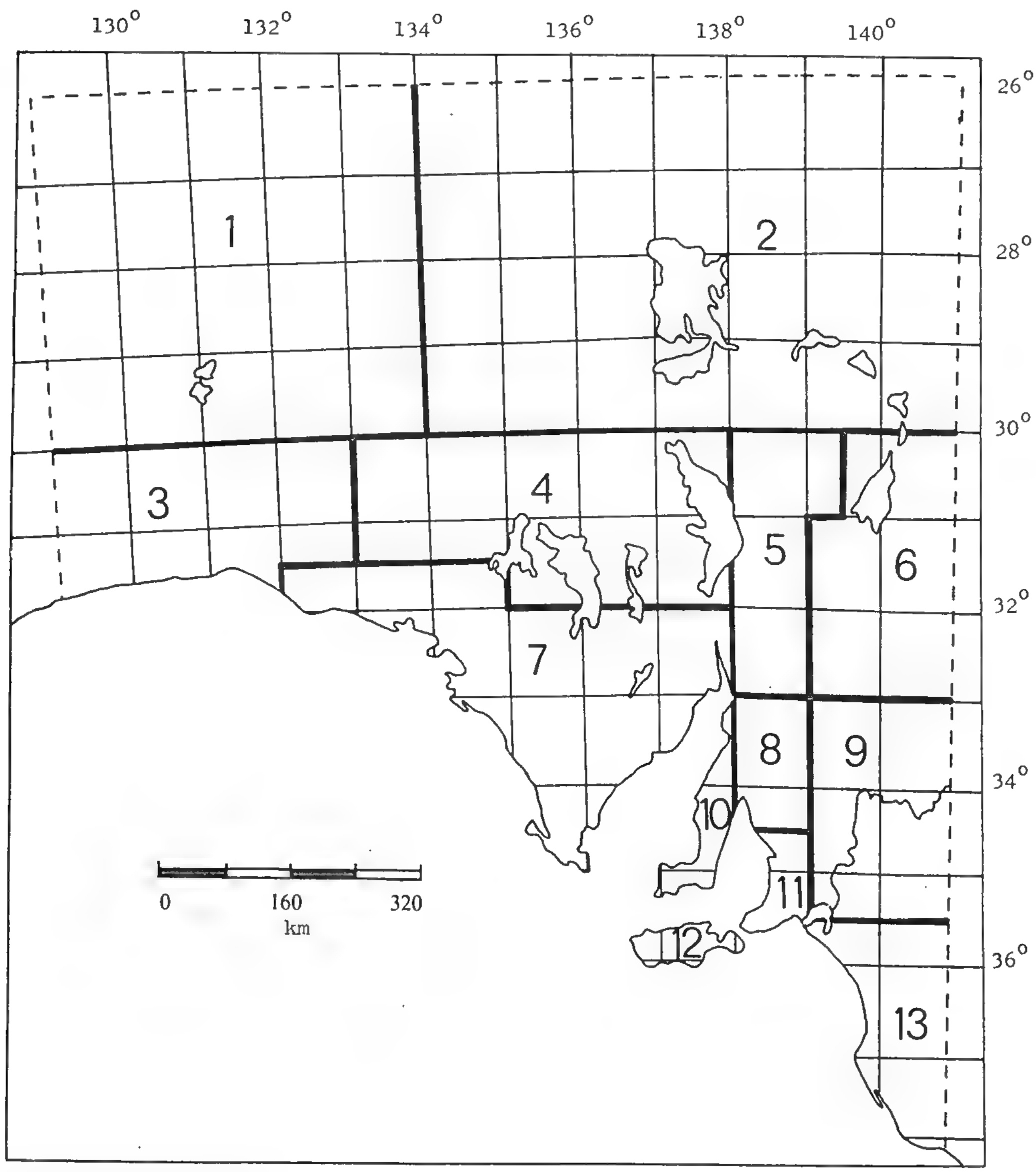
Cunningham, G.M., Mulham, W.E., Milthorpe, P.L. & Leigh, J.H. 1982 (dated 1981). 'Plants of western New South Wales', pp. 766, figures 67, colour plates approximately 1490, 1 map (endpapers). (Published by the N.S.W. Government Printing Office in association with the Soil Conservation Service of N.S.W., Sydney). Hard-bound.

Jacobs, S.W.L. & Pickard, J. 1981. 'Plants of New South Wales. A census of the cyads, conifers and angiosperms', pp. 226, 1 map (endpapers). (Published by D. West, Government Printer, Sydney). Hard-bound. $18.00.

J.P. Jessop
State Herbarium of South Australia.

REGIONS OF SOUTH AUSTRALIA ADOPTED BY THE STATE HERBARIUM — ADELAIDE

1. North-western
2. Lake Eyre Basin
3. Nullarbor
4. Gairdner-Torrens Basin
5. Flinders Ranges
6. Eastern
7. Eyre Peninsula
8. Northern Lofty
9. Murray
10. Yorke Peninsula
11. Southern Lofty
12. Kangaroo Island
13. South-eastern



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JOURNAL of the ADELAIDE BOTANIC GARDENS

CONTENTS

JOURNAL of the ADELAIDE BOTANIC GARDENS

Volume 6 Part 2

9 May, 1983

Instructions to Authors

Topics

Papers will be accepted in the following categories:
(a) Plant systematics (Australian and horticultural groups); (b) Descriptive plant morphology, anatomy and ecology; (c) Obituaries, biography and history; (d) Bibliographic studies, book reviews; (e) Botanical illustrations; (f) Noteworthy horticultural contributions.

Copy

Manuscripts must be typed, with double spacing and margins at least 3 cm wide, on one side of the paper only. Three copies must be submitted. Captions must not be italicized, underlined or typed in capitals. All scientific names of generic or lower rank must be underlined.

The print area for illustrations is 18 x 13 cm (excluding captions). Half-tone material should be submitted this size if possible, but will be reduced by the printers, if necessary.

Reprints

50 copies of reprints will be provided for each paper. Additional reprints may be purchased at cost.

Layout

The pattern of the paper should generally be:
(i) Title; (ii) Author and Address; (iii) Abstract (except for short papers); (iv) Introduction and subject matter; (v) Acknowledgements; (vii) References.

References

Text references to publications should be indicated as follows: (Smith, 1959), (Smith, 1959, p. 127), Smith (1959) or Smith (1959, pp. 125-208). The final section of the paper, headed 'References', should include only those titles referred to in this way. It should be laid out as follows:

Smith, L. L. (1879). The species of *Danthonia* found in pastures in Victoria. *Austral. J. Bot.* 65: 28-53.

Bentham, G. (1868). "Flora Australiensis", Vol. 4. (L. Reeve: London).

Baker, J.G. (1898). Liliaceae. In Thiselton-Dyer, W. T. (ed.). "Flora of Tropical Africa", Vol. 7. (L. Reeve: Ashford).

Journal abbreviations must be consistent within a paper and authors are recommended to follow "Botanico-Periodicum-Huntianum". Journals not cited in B-P-H should be abbreviated to conform with this general pattern. The following abbreviations for Australian states should be used: WA, NT, SA, Qld, NSW, ACT, Vic., Tas.

Text references to specimens should be italicized, for example *Kock 276.*

Indices

When required, follow the pattern on, for example, p. 106 of vol. 1, pt. 2.

Recommendations on taxonomic papers

Synonymy

Authors are requested to include in the synonymy only references to publications containing information additional to that to be published in the paper being submitted. Within this section journal and book titles must be conistently abbreviated. B-P-H journal abbreviations and book titles abbreviated in a similar way are desirable. Authors of references cited in the synonymy should preferably be abbreviated according to the 'Index of Author Abbreviations' compiled and published by Royal Botanic Gardens, Kew (1980). References may be cited as:

Benth., *Fl. Austral.* 4: 111 (1868) OR
Benth., *Fl. Austral.* 4: (1868) 111.

Citation of specimens

10-30 specimens should be cited for each species (or subspecific taxon), although this may be varied under certain circumstances. The author may decide whether or not to include dates of collections and the sequence, provided a constant pattern is adhered to throughout a paper.

Authors wishing to cite all specimens seen may list them all in an index to collectors after the style of the "Flora Malesiana" identification lists. Collections not identifiable by a collection number (assigned by either the collector or herbarium) should cite dates.

Correspondence

All correspondence concerning the journal should be addressed to:

The Director, Adelaide Botanic Gardens, North Terrace, ADELAIDE, South Australia 5000.

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EARLY RECORDS OF ALIEN PLANTS NATURALISED IN SOUTH AUSTRALIA

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Abstract

A search of collections and early literature revealed that 101 species of alien plants were naturalised in South Australia by 1855. Another thirteen alien species were erroneously recorded as naturalised and native taxa were mistakenly identified as alien species in a further seven instances. All of the species are presented in an annotated list, including citations of relevant specimens. Observations by various botanists on alien plants in that period are reviewed. Of the established species, 90 originated in Europe, and 55 are known to have been introduced on purpose.

Contents

Introduction

An earlier paper (Kloot, 1980) critically reviewed the first publication specifically devoted to the naturalised plants of South Australia (Schomburgk, 1879). The literary material relating to this subject prior to Schomburgk's pamphlet is extremely scanty and may be divided into two classes according to its reliability. The first is the material published by botanists. The literary references in this case are largely supported by specimens although, unfortunately, there has been some loss due to the misplacement of material and the unsatisfactory curation of various collections in the past. Material of the second class is both fragmentary and scattered and consists of the passing comments of agriculturalists, gardeners and others on naturalised plants, generally weeds. There is great variability in the reliability of these references, and one requires a knowledge of the commentator and the names, colloquial and botanical, that were used at different times and in different places.

In this paper, publications by the more reliable botanists are reviewed in chronological order and the other references that have been located in contemporary publications are considered in relation to them.

Plant Introduction and Naturalisation

Although it has not always been done in the past (e.g. Ewart and Tovey, 1909; Piggin, 1977) it is essential to make the distinction between introduction and the later process of naturalisation. The former may be accidental or intentional. Where plants were introduced on purpose there were a number of motives, some of which, with hindsight may seem strange. Pasture, crop and culinary plants were obvious choices for introduction but there were also ornamentals, hedge plants, medicinals, fibre plants, vermifuges and "novelties", a number of which subsequently escaped from cultivation. Regardless of their manner of introduction, naturalised species are those which, having been introduced, maintain themselves indefinitely (or at least through several generations) in the wild or in man-made habitats without feeding or cultivation (Wace, 1978).

In the case of aggressive plants, the ruderals or weedy species, the period between introduction and naturalisation may be as little as one growing season but with slower growing woody trees and shrubs there may be over 100 years between the documented introduction of a species and its naturalisation. Furthermore the majority of plants that have been introduced have not escaped to become naturalised although it may be allowed that many could do so in the future.

The respective documentation of each of the two processes is quite different. Introduction is supported by nurserymen's lists, botanic garden catalogues and other records provided by the earliest introducers often proclaiming the virtues of their introductions for whatever purposes they deemed them fit. However, naturalisation was not recorded except as an afterthought to the writings of botanists who concentrated on the native flora or to the passing comments of people affected one way or another, usually adversely, by the introduced plants.

Furthermore, apparent records of naturalisation must be supported by other evidence that the plants were truly naturalised at that time. Here annotations to herbarium sheets are invaluable as are comments published by independent observers. A single or a few specimens can be misleading and examples will be given later where species were wrongly considered to be naturalised on such a basis.

The First Collectors

The first botanical collections made in South Australia were those assembled by Robert Brown in 1802. Prior to the voyage of Matthew Flinders, in which Brown participated, there was no known European contact with South Australia although Wace (in press) concludes from a passage in Flinders' logbook that there could have been sealers off the South Australian coast at that time. As would be expected, Brown's collections do not contain any alien plants but are mentioned here because of an error associated with one of the specimens.

Bentham (1868) cites a specimen of *Heliotropium europaeum* L. collected by Brown at the top of Spencers Gulf. As this species is recognised by all authorities as being introduced to Australia from Europe, this early collection is clearly anomalous. Black (1909) considered it to be another species, *H. eichwaldii* Steud., but more recently D.E. Symon (pers. comm.) has advised me that the specimen is very poor and its identity is uncertain; it is possibly a species of a native genus.

The next botanical collections from South Australia were those made by and for Governor George Grey in the early 1840s, and were lodged in his wife's name (Mrs. Eliza Lucy Grey) at the British Museum (Natural History) (Lanjouw and Stafleu, 1957). Some sheets of *Lythrum salicaria* L. were found in Melbourne (MEL!). One is dated

27 December 1843 and annotated "Flats at the other side of the river going to Burra" whilst the other dated December 1843 is labelled "Plants growing in the watercourses north Para river". The flats were where the main road crossed the North Para River at Gawler. This ford was at the edge of a property "Clonlea" owned by John Reid whose daughter later wrote about the early days. Amongst other things she wrote ". . . . . and I collected and dried all the flowers (new) we could find to give to Captain Grey who was making a botanical collection" (Mahoney, 1928). To Elizabeth Sarah Mahoney (nee Reid) *Lythrum* must have been a "new" plant but as the Reids came from Northern Ireland where this plant is less common (Perring and Walters, 1976) perhaps they did not recognise a fellow immigrant. On the other hand karyotypic differences are known to exist between Australian and European forms of the species, the former being diploid ($2n = 30$) and the latter tetraploid (Curtis, 1963; Webb, 1968). If it is an alien plant that arrived after European contact its presence at Gawler could be explained by the movement of propagules on sheep travelling north from Adelaide. The collection site, being well watered flats, would have been a convenient site to break the journey northwards. However, it is more likely to be a typical semi-aquatic plant that is moved about on birds' feet (Ridley, 1930) and although it originated in the northern hemisphere its appearance in South Australia may have preceded the advent of Europeans. It may be relevant that Brown (1814) recorded it as "native to both Terra Australis and Europe" which implies that it must have been well established when he collected it. Also Schlechtendal (1847) recognised the specimens collected by H.H. Behr near Tanunda as an Australian form *L. salicaria* f. *tomentosum* which differed from the European taxon, a distinction that could reflect differences in ploidy. A future examination of the material at BM may reveal other specimens and hopefully there may be one or more species of less doubtful provenance.

The German Collectors

In 1844 a period of intense collecting around Adelaide and the settled areas began. As most of the botanists involved were German the group as a whole has been so labelled. W. Hillebrand and W. Blandowski collected in the Adelaide area. Behr was active in the Barossa Valley and C. Wilhelmi collected near Port Lincoln. E.G. Sealy and H. Heuzenroeder were active on Kangaroo Island and F.J.H. Mueller ranged more widely. These workers traversed well-established areas and they collected alien as well as native plants. There were other explorations such as those of Charles Sturt to the interior from 1844 to 1846 but these did not record introduced plants. This period of activity ended within 10 years when all of the botanists listed left South Australia for various reasons or ceased collecting. Apart from the botany undertaken during the major expeditions into the interior of Australia there was little activity in South Australia until the late 1870s.

The collections assembled by the botanists enumerated above, apart from Behr's first collection, found their way to George Bentham at Kew, England either through his main collaborator Mueller at Melbourne, or through a parcel of South Australian material sent in 1864 by George Francis, the first Director of the Adelaide Botanic Gardens, to Sir William Hooker, the Director of the Kew Gardens. The Mueller material was returned to Melbourne and remains there but the material sent from Adelaide, although returned, has since disappeared.

The material gathered by these collectors will be discussed below, but before this, the writings of two of them on alien plants in South Australia will be examined.

H.H. Behr

Dr. Hermann H. Behr made two trips to South Australia from 12 September 1844 to

9 October 1845 and from 6 November 1848 to some time in 1849 (Kraehenbuehl, 1981). In 1847 he published an article in *Linnaea* (Behr, 1847) on the flora of South Australia. This was translated by Richard Kippist of the Linnean Society and published four years later (Behr, 1851). After describing the native flora he concluded with the following paragraph:

"The Australian flora has been but little enriched by any European plant except cultivated ones. We find indeed here many that are identical with European plants but the native home of most of them is a very critical (kitzlicher) point while the Australian burgher right (Burgherrecht) of others is beyond all doubt. As might naturally be expected my researches upon this point have not led to any certain results. The following plants appear however to me to be unquestionable immigrants viz. *Lolium temulentum*, *Centaurea cyanus* (rare), *Capsella bursa*."

It should be noted that Behr's article referred to his observations during his first visit to South Australia. The collection from this visit is now in Halle but enquiries there did not succeed in locating the particular species cited. However, from other sources, the following information has been assembled.

Lolium temulentum

This name was used indiscriminately for annual forms of *Lolium* found in crops, a generalisation that goes back to Linneaus (1753). It is an obligate crop weed (Zohary, 1962) introduced with contaminated grain. Possibly it grew only in crops for which the seed had been imported as *L. temulentum* L. is very rare in South Australia. Available evidence (Kloot, unpubl. data) suggests that *L. rigidum* would probably have been more important particularly in crops grown from locally produced seed. Therefore, many agronomic references and botanical records of *L. temulentum* actually refer to *L. rigidum* or even other *Lolium* spp. The results of investigations in this matter will be presented elsewhere.

Centaurea cyanus

This species, cornflower, has never been recorded as naturalised in South Australia. Two possible explanations are suggested. Firstly, this species was a common contaminant of grain in Europe (Loudon, 1835). It may have been imported in grain from there and grown in the subsequent crops but failed to set seed and persist under local conditions. Alternatively, as Behr wrote the article after he left South Australia he may have remembered incorrectly the blue-flowered *Cichorium intybus* L. as *Centaurea cyanus* L. which is similarly-coloured. *C. intybus* was a very early introduction having been sown by the first settlers (Capper, 1838) and known to have persisted from the first plantings (Anon., 1878).

Capsella bursa

This is *C. bursa-pastoris* L., shepherd's purse, a weedy species that is widespread throughout the world. It originated in Eurasia, but its introduction to South Australia is unknown. It was collected by Mueller in 1848 around Adelaide (MEL!). Behr's reference was supported by a specimen which Schlechtendal verified and was included in his enumeration of South Australian plants collected by Behr (Schlechtendal, 1847). Unfortunately the specimen itself could not be found (K. Werner, pers. comm.). Schlechtendal noted that *C. bursa-pastoris* was found in cultivated places, waste places and abandoned sheep camps. In England, it was noted as a crop weed and hence a potential seed contaminant (Loudon, 1835).

In a paper many years later Behr (1891), whilst discussing the provenance of a species of the California flora which was being debated at that time, made passing reference to two species whose "sudden invasion" of South Australia he had seen. Because of the short periods that he was in South Australia, I suggest that the "sudden invasion" did not occur during either of his visits but rather in the years between his visits i.e. from 1845 to 1848. The two species were *Silybum marianum* L., variegated thistle, in the past more usually known as milk thistle, and *Cotula coronopifolia* L., batchelors' buttons.

Silybum marianum

According to Schomburgk (1879) this was said to have been introduced as a garden plant in 1846. This supports the suggestion made earlier that it was introduced between 1845 and 1848, but no other evidence has been found for Schomburgk's quite definite assertion as to the date. There are no collections by Mueller, and Bentham (1867) does not record it for South Australia. Yet by 1851 it had spread to such an extent that it was included specifically in the Thistle Act of that year.

Cotula coronopifolia

This very early introduction to Australia was collected by R. Brown at Port Jackson, N.S.W., between 1802 and 1804—MEL! (Britten, 1906). It was collected widely by Mueller around Adelaide and found in wet areas throughout the State in later years (MEL!). Its widespread distribution in this State and Australia generally led Bentham (1867) to conclude that it was native. But Mueller (1868) unequivocally considered it to be an early and successful introduction from South Africa. Later authors (e.g. Robertson, 1957; Willis, 1972) have persisted in the error of regarding it as a native. No other evidence for the date of introduction has been found.

F.J.H. Mueller

Dr. Ferdinand Mueller lived in South Australia from 15 December 1847 to late 1852 (Gemmell, 1975; Churchill *et al.*, 1978). Two papers which refer to introduced plants in South Australia were located. There are other references to introduced plants in general, some of which are mentioned in the present paper. Mueller's greatest contribution to the subject is his collection which will be discussed below.

In the first paper (Mueller, 1850) which appeared as a letter in an Adelaide newspaper, he mentioned *inter alia* that *Gnaphalium album* (sic) had been introduced from Europe and by then was growing almost everywhere. He also noted that Cruciferae and Compositae in the neighbourhood of Adelaide had so changed the appearance of the land that apart from the eucalypts, the vegetation appeared more European than Australian.

Gnaphalium luteo-album

Mueller used the name *G. album* in error. Bentham (1867) cited widespread locations from all parts of Australia. The species is very variable and its provenance is uncertain. Drury (1970) noted that the section of the genus to which this species belongs, is centred in the Indo-Malay region, from where it has spread widely and it is possible that distinct European and Australian forms exist. European forms may have been introduced to Australia after settlement but most authors regard it as being native to Australia. One exception was Schomburgk (1875) who listed it as one of the more troublesome weeds of the State at that time, and in the context implied that it was introduced. Mueller's statement, whilst unequivocal, may be only partly correct. It may have been present before settlement, but the disturbance of the native vegetation

presented it with much larger areas suitable for its success than had been previously available.

Regarding the Cruciferae and Compositae, Bentham (1863) recorded nine species of the former as being present in South Australia whilst fifteen species of Compositae were recorded by Bentham (1867). However, one was a misidentification, and there were at least two others not recorded by Bentham or collected by Mueller in South Australia. These were *Cirsium vulgare* and *Silybum marianum* which were the targets of the Thistle Act of 1851. Apart from these two thistles all other species alluded to here are represented by specimens at MEL!

The second paper (Mueller, 1853) is a translation by Richard Kippist of an article written in German. This concerned the native flora but in two places referred to naturalised plants. Firstly (p. 67), he wrote ". . . nearly 100 species are already to be added [to the native flora], which, having migrated, partly from Europe, partly from the Cape, have become naturalised here, beyond the possibility of extirpation". It will be shown later, mostly from Mueller's collections, that there were 101 species naturalised at that time in South Australia.

His second passage is "How powerfully the transforming influence of the imported vegetation acts upon the original flora may be readily observed in the neighbourhood of Adelaide, where the Australian grass, now growing only in scattered tufts, has made way for a thick turf of *Poa annua, Briza, Koeleria* etc." The passage concludes with Mueller predicting that the spreading of "nomadic grasses" in the interior would probably bring great benefits to the interior of Australia just as the country where grain was grown had already been improved by the increase in rainfall that it caused. This was an expression of the erroneous belief that "rain follows the plough" which had such disastrous results for the marginal agricultural areas of South Australia (Meinig, 1962).

Mueller, apart from mentioning the deterioration of the native flora with the spread of settlement, lists three grasses, for which the following details have been gathered.

Poa annua

This species, *Poa annua* L., winter grass, was collected by Mueller in May 1848 (MEL!) and one of his sheets has the annotation that it was frequent around Adelaide. Slightly earlier McEwin (1847) had also noted it as common in South Australia. Bentham (1878) wrote that it was regarded as abundant in South Australia but no specimens were cited. It was an early introduction to Australia having been collected by Brown at Port Jackson between 1802 and 1804 (Britten, 1906). Formerly, it was recognised as being a useful fodder grass in England providing early feed (Sinclair, 1815; Loudon, 1835), and could well have been introduced for that purpose.

Briza

Two species, *B. maxima* L., quaking grass, and *B. minor* L. shivery grass, were present in South Australia in the 1840s. The former was a popular ornamental grass (Bentham, 1878; Anon., 1879) which was introduced to South Australia before 1843 (McEwin, 1843) and it could have escaped into suitable habitats quite early. Mueller collected it at Echunga in spring, 1848 and there is another collection, possibly also by Mueller from the Torrens River in November 1849 (MEL!). Towards the turn of the century it had become well-established quite widely in moist places in the Adelaide Hills. The second species was also regarded as an ornamental in Britain (Loudon, 1830), but apart from its being grown in the Botanic Gardens I could not locate any other evidence of its horticultural use at that time in this country. By Mueller's time it was widespread in the settled areas of South Australia, and was collected by him, Blandowski and

possibly others from the Adelaide area, the Adelaide Hills, the Barossa Valley and Mount Gambier (MEL!). McEwin (1847) mentioned that he had seen a species of *Briza* in the Colony, but that it was quite rare.

Koeleria

K. phleoides (Vill.) Pers. was collected by Mueller around Adelaide (MEL!). It is a weedy grass and was probably introduced accidentally. It spread rapidly, and had reached Fowlers Bay by 1880 (MEL!). Now it is widespread throughout the State. No earlier record has been located.

The *"Flora Australiensis"* (including a complete list of species)

This monumental work was produced by George Bentham working at Kew in England between 1863 and 1878. This period is somewhat later than that of the German collectors, and it may be assumed that there would have been a considerable change in the introduced flora in the intervening period. However, for the reasons stated earlier, the *Flora Australiensis* understandably reflects the alien flora of South Australia during the period to Mueller's departure in 1851 rather than that contemporaneous with its publication. Therefore, it is appropriate to consider its array of alien plants in South Australia at this point. It should be pointed out that some species collected by Mueller were omitted from the *Flora* for one reason or another and in a few cases there is external evidence that suggests certain plants were naturalised but neither Mueller nor the other collectors gathered them and consequently they were not mentioned by Bentham.

In the following listing, all plants now considered to be alien to South Australia are included, regardless of Bentham's opinion as to their status. For completeness, the list contains all species considered to be present but those not recorded for South Australia by Bentham are discussed here later. Such names are preceded by an asterisk. Native plants which Bentham erroneously regarded as identical to overseas species and that were included in the *Flora* under that "alien" name are also noted. The species are listed in their order in the *Flora*. Where Bentham's name is not currently accepted, the present name is shown in brackets. Volume and page references, statements and quotations preceded by F.A. and enclosed in brackets are respectively cited, paraphrased or reproduced verbatim from the *Flora*. Many annotations by Mueller and others are in Latin and occasionally German. These have been translated. In a number of cases, Mueller noted the month but not the year. Such dates have been given as - ii.?. Most South Australian localities mentioned are shown in Figure 1. Hake's place is a misspelling of Hack's place, being the property of J.B. Hack at Echunga.

RANUNCULACEAE

Ranunculus aquatilis L. (*R. trichophyllus* Chaix)

(F.A. Volume I, page 10. Native. "Near Adelaide, on the Lower Murray river, etc., *Behr, F. Mueller*".)

Mt Barker Ck, *Mueller*, ix.1848; R. Murray, nr Wellington, *Mueller*, x.1848; Kaiserstuhl, *Mueller*, i.1849; Holdfast Bay, *Mueller*, s.d.—MEL!

The introduction of this species to South Australia from Eurasia is uncertain.

PAPAVERACEAE (FUMARIACEAE)

Fumaria officinalis L.

(F.A. I, 63. "one, at least, of the numerous forms of the European *Fumaria officinalis*

has established itself as a weed of cultivation in some parts of Victoria and South Australia".)

North Adelaide, *Mueller*. s.d. c. 1850, MEL! originally identified as *F. eckloniana* Sonder. Black (1909) included both *F. capreolata* L. and *F. muralis* Sond. ex Link in *F. officinalis*.

Its introduction to South Australia is uncertain but it was held in great repute as a medicinal plant in the past (Bailey 1943), so it may have been introduced for that reason, but it was also a common contaminant of cereals (Loudon, 1835).

PAPAVERACEAE

Papaver horridum DC. (*P. aculeatum* Thunb.)

(F.A. I, 63. Considered to be native to Australia and South Africa. "Murray scrub, towards Mount Barker and Flinders Range, *F. Mueller*".)

Murray scrub towards Mt. Barker, *Mueller*, x.1848; gullies of the Flinders Ra., *Mueller*, x.1851; Adelaide, *Herb. Mueller*, s.d.—MEL!

This species is of South African origin probably introduced unintentionally by the earliest settlers (Mueller, 1868; Burbidge and Gray, 1970).

* *Papaver rhoeas* L. See page 122.

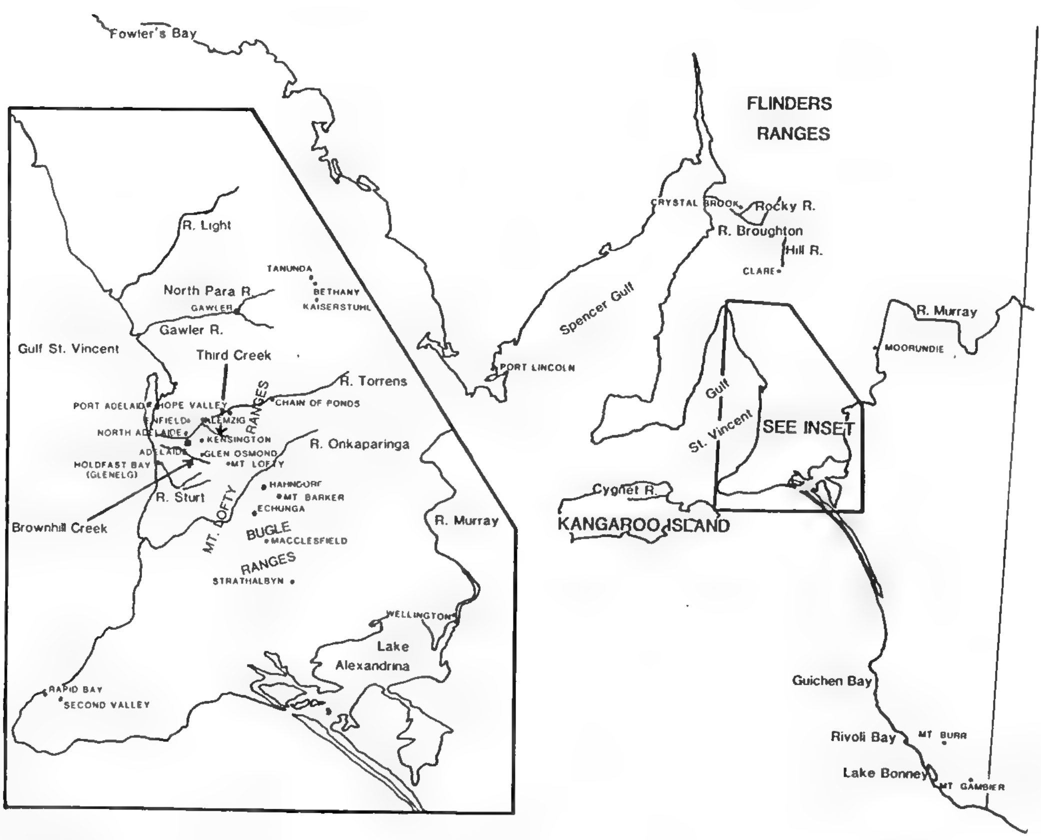

Fig. 1. South Australia, showing localities mentioned in the text.

CRUCIFERAE

Nasturtium officinale R. Br. (*Rorippa nasturtium-aquaticum* (L.) Hayek)

(F.A. I, 65. "... in a few streamlets in Victoria and South Australia; but everywhere its importation from Europe could be traced".)

R. Torrens, *Mueller*, 1849; Crystal Brook, *Mueller*, xi.1851—MEL!

Introduced as a vegetable (watercress) by Mrs M. Davenport and planted at Macclesfield by 1844 when it was washed out by a flood into the Onkaparinga River from where it spread naturally or was introduced to other watercourses (Bailey, 1879; Baldwin, 1967).

Nasturtium palustre DC. (*Rorippa islandica* (Oeder) Borbas, syn. *Rorippa palustris* (L.) Besser).

(F.A. I, 65. Native. "Torrens river, near Adelaide, *F. Mueller*".)

R. Murray, *Mueller*, i. ?; R. Torrens at North Adelaide, *Mueller*, 23.i.1848; St. Vincent's Gulf, *s.l.*, s.d.—MEL!

Of uncertain introduction but possibly confused with the previous species.

Cardamine hirsuta L.

(F.A. I, 70. Native. "As far as the Flinders Ranges, *F. Mueller*".)

In the MEL collection there are ten specimens that were collected by Mueller and named by him *C. debilis* Banks, which Bentham cites as a synonym of *C. hirsuta*. However, they all are endemic species and have been determined as such by Dr. H.J. Hewson (pers. comm).

Alyssum linifolium Steph. ex Willd.

(F.A. I, 71. "... may possibly have been introduced from southern Europe, but it appears to be too abundant in arid desert situations to be omitted from the Flora". "Near Crystal Brook and about Spencer's Gulf, *F. Mueller*".)

Wellington on R. Murray, *Mueller*, 5.x.1848; betw. Strathalbyn and Wellington, *Mueller*, x.1848—MEL!

No specimens that could be related to Bentham's citation were found. Of unknown but early introduction.

Sisymbrium officinale L.

(F.A. I, 72. "... so well established as a roadside weed that it cannot be omitted from the Flora". "Abundant on roadsides and waste places about Adelaide, *F. Mueller and others*".)

Light River, *Mueller*, xii.?; in waste places and roadsides about Adelaide, *Mueller*, xi.1848—MEL!

According to Schomburgk (1879) it came from Tasmania, but as it is a common plant in Europe (Fitter, 1978) it could have come direct. It was cultivated for oil in England (Loudon, 1835), and may have been introduced for that purpose.

Capsella procumbens (L.) Fries. (*Hymenolobus procumbens* (L.) Nutt. ex Schinz & Thell.)

(F.A. I, 81. Widespread plant through the Mediterranean and adjacent areas, native to Australia. "Near St. Vincent's Gulf and Lake Alexandrina, *F. Mueller*; Guichen Bay, *H. Edwards*".)

Wellington, *Mueller*, 5.x.1848; Hill R., *Mueller*, x.1851; Pt Adelaide, *Mueller*,

viii. 1852; Guichen Bay, *s.l.*, viii.1860—MEL!)

Of uncertain introduction.

Capsella bursa-pastoris Moench.

(F.A. I, 82. ". . . has now established itself in cultivated places in several of the Australian colonies".)

About Adelaide, *Mueller*, viii.1848—MEL!

See page 96.

Senebiera didyma Pers. (*Coronopus didymus* (L.) Sm.)

(F.A. I, 83. ". . . perhaps indigenous to N. Australia, and now established in the neighbourhood of towns in almost all the colonies".)

In valleys of Mt. Lofty Ra. and about Adelaide, *Mueller*, ii.1848; betw. Pt. Adelaide and Hahndorf, *Blandowski*, 1850—MEL!

This is a common weed of southern Europe but its introduction to Australia is uncertain.

Lepidium ruderale L. (incl. *L. hyssopifolium* Desv. and native spp.)

(F.A. I, 86. Native. "Abundant in many localities, especially about salt marshes and in waste places, *F. Mueller and others*".)

Bentham used *L. ruderale* in error for a number of species including *L. hyssopifolium*. The latter was considered to be native but recently has been judged to be a South African species (Carolin and Hewson, 1981) possibly conspecific with *L. africanum* DC. (Ryves, 1977).

CARYOPHYLLEAE (CARYOPHYLLACEAE)

Gypsophila tubulosa Boiss.

(F.A. I, 155). In error for the native *G. australis* (Schldl.) A. Gray (See Eichler, 1965).

Silene gallica L.

(F.A. I, 155. ". . . introduced into Australia." ". . . established in several Australian colonies . . .".)

Bugle Ra., *Mueller*, xi.1848; nr Mt Lofty, *Mueller*, 23.xii.1848; nr the small fresh-water lagoon at the Three Wells R., *Waterhouse*, s.d.—MEL!

Waterhouse's specimen would have been collected about the middle 'fifties. Three Wells River was a former name for the Cygnet River, Kangaroo Island. A collection by Tepper s.d. at AD! is annotated "Introduced by the first settlers about 1840". Probably introduced as a grain contaminant.

Lychnis githago Lam. (*Agrostemma githago* L.)

(F.A. I, 156. ". . . has been introduced with European corn into some of the Australian colonies . . .".)

Bugle Range, *Mueller*, 22.xii.1848—in oat and barley crops—MEL!

This is the only Australian specimen at MEL and has been included in the reference collection. It is ill-adapted for South Australia and was not collected again until 1967 when E.H. Ising made a collection at Crafers where it had escaped from a garden onto a roadside (AD96750578!). It was a common grain contaminant in England (Loudon, 1835) and thus was introduced here, but it failed to persist under local conditions. It was reintroduced later as a garden plant and is found occasionally in the highest rainfall areas of the Mt. Lofty Ranges.

Cerastium vulgatum L. (*C. glomeratum* Thuill.)

(F.A. I, 156 "... perhaps introduced only." "In good soils, *Behr*".)

Bethany, *Mueller*, ii.1848; betw. Mt Barker and R. Murray, *Mueller*, x.1848; Twofold Bay, *Mueller*, s.d.; main road betw. Pt Adelaide and Hahndorf, *Blandowski*, 22.ix.1849; Clare village, *s.l.*, 1857—MEL!

A common ruderal probably introduced accidentally very early. Collected by Behr in 1844-45 from fertile soils. No specific localities are cited (Schlechtendal, 1847). Noted as one of the most troublesome weeds by McEwin (1847).

Stellaria glauca With. (*S. palustris* Retz.)

(F.A. I, 158. "... truly indigenous, but identical with a European species". "Extending to St. Vincent's Gulf, *F. Mueller*".)

Mt. Lofty Ra., *Mueller*, 10.i.1848 (2 specimens); Murray R., *Mueller*, 1851—MEL!

Another common ruderal probably introduced accidentally, very early.

Stellaria media (L.) Vill.

(F.A. I, 159. "... a common weed in cultivated places, especially gardens, as well as in waste places, almost all over the globe, and as such is found in most of the Australian colonies ...".)

Third Ck, *Mueller*, 3.ii.1848—MEL!

As Bentham noted, it is a common weed of gardens and also of crops (Loudon, 1835) and was probably introduced inadvertently.

Arenaria serpyllifolia L. (*A. leptoclados* (Rchb.) Guss.)

(F.A. I, 159. "... now almost naturalised in several of the Australian colonies".)

Clare village, *s.l.*, 7.xi.1857—MEL!

This is a freely seeding annual found in cultivation, particularly in gardens and would have been introduced by the first settlers.

Sagina procumbens L.

(F.A. I, 160. Native. "St. Vincent's Gulf, lofty ranges, etc. *F. Mueller*".)

Mt Lofty Ra., Mueller, xi.?; Adelaide, *Mueller*, 21.xi.1848—MEL! Another common ruderal, readily moved as a result of human activities.

Spergula arvensis L.

(F.A. I, 161. "... now dispersed over various parts of the world as a cornfield weed, and introduced as such into the Australian colonies ...".)

Macclesfield, *Mueller*, ix.1848—MEL!

The specimen was probably found in a crop having been introduced in contaminated seed, although it was also sown as a fodder plant in wheat stubbles in England (Loudon, 1835). It is not, and never seems to have been, common in South Australia.

Spergularia rubra (L.) J. & C. Presl. (includes *S. media* (L.) Presl.)

(F.A. I, 161. Native "Near Adelaide, St. Vincent's Gulf, etc. *F. Mueller*".)

Klemzig, *Mueller*, 1848; St Vincent's Gulf, *Mueller*, 7.ii.1848; Murray plains, Murray R., *Mueller*, ii.1848 (2 specimens); Lake Victoria, *Mueller*, 28.iv.1848—MEL!

Other material originally identified as *S. rubra* has since been determined as *S. media*, viz:-

LeFevre Penin., *Mueller*, 16.xii.1847; Lake Alexandrina, *Mueller*, iv.1848; nr Georgetown, *Mueller*, xi.1850; Brighton, *Mueller*, xi.1852—MEL!

The reference to Lake Victoria is probably an error for Lake Alexandrina where Mueller did collect in April 1848. The specimen from Brighton could be Brighton, Victoria, as it is not certain when he actually left Adelaide for Melbourne (Churchill *et al.*, 1978).

Both these species are ruderals commonly found around gardens and waste places in Europe and could have been introduced accidentally by early settlers. But being inhabitats of sub-marshy areas, their introduction could have also been associated with the movement of birds between similar environments. The species was listed by Schlechtendal (1847) under a synonym *S. rupestris* Cambess. as having been collected by Behr in 1844-45 in seasonally flooded grassland at Bethany.

Polycarpon tetraphyllum (L.) L.

(F.A. I, 163. Native. "Near Adelaide, *Herb. Mueller*".)

Valley nr Mt Lofty, *Mueller*, 28.x.1847; Adelaide, *Mueller*, 1848—MEL!

This freely-seeding annual is also commonly found in gardens and would have been yet another inadvertent introduction.

PORTULACEAE (PORTULACACEAE)

Portulaca oleracea L.

(F.A. I, 169. Native. "Elizabeth Creek, in the interior, *Babbage's Expedition*".)

The reference here is undoubtedly to a native taxon found in the interior of Australia. The weedy species or form which is identical to overseas material was not collected in South Australia until 1885 and this could have come from escaped horticultural material (Kloot, 1980).

Calandrinia caulescens H.B. & K. (*C. menziesii* (Hook.) Torr. & Gray)

(F.A. I, 175. ". . . a common Peruvian weed has established itself in waste places about Adelaide and other parts of S. Australia".)

Grain crops Hake's (Hack's) place, *Mueller*, 22.ix.1848; Mt Burr, *s.l.*, x.1848; Parkland nr Adelaide, *Mueller*, s.d.—MEL!

A sheet at MEL has been annotated by Mueller "This I have never published for altho' widely spread it may prove not indigenous." From this it may be concluded that it must have been well spread amongst the native vegetation, although native *Calandrinia* spp. could have been included, as well. However, both Mueller and Bentham seem to agree that this species is introduced. Contrary to Bentham's comment, it is a North American species. Closely related species were grown in England as ornamentals (Loudon, 1830) so this species may have been introduced for this purpose. Certainly one species was available commercially from Sydney in 1843 (Anon., 1843) and as there were commercial links between Sydney and Adelaide nurserymen (Bailey, 1845), this could be further evidence.

MALVACEAE

Malva parviflora L.

(F.A. I, 186. "Four common European species [of *Malva*] have become naturalised as weeds in some of the colonies"—no localities given.)

Waste plains in Adelaide, *Mueller*, 28.xii.1847; St Vincent's Gulf, *Mueller*, s.d. (c. 1850)—MEL!

Probably a garden escape (Schomburgk, 1879).

Malva verticillata L.

(F.A. I, 186.)

As for the previous species.

It was possibly grown in gardens in South Australia at the time but Bentham's identifications are incorrect, the material was actually *M. parviflora* (Barker, 1977).

ZYGOPHYLLEAE (ZYGOPHYLLACEAE)

Tribulus terrestris L.

(F.A. I, 288 "N. of Lake Torrens, *McDouall Stuart's Expedition*".)

Finke R, *s.l.*, s.d.; N. of Fowler's Bay, *s.l.*, s.d.—MEL!

The cited specimens are densely hairy native forms commonly found in the interior and adjacent settled areas. The form found in the South, particularly in the Adelaide area, is an introduced form identical to overseas material that was collected only much later. The earliest collection of this form is a specimen in Black's herbarium (AD) collected at Mile End on 25.ii.1924. The material cited by Bentham is a native taxon of uncertain status.

Nitraria schoberi L.

(F.A. I, 291).

In error for the endemic species, *N. billardierii* DC. (Noble and Whalley, 1978).

GERANIACEAE

Geranium dissectum L.

(F.A. I, 296.)

In error for a number of endemic species (Carolin, 1964). However, *G. dissectum* did become naturalised much later (Symon, 1964).

Erodium moschatum (L.) L'Her. ex Ait.

(F.A. I, 297. "Has established itself as a weed in some parts of Victoria, S. Australia and W. Australia".)

North Adelaide, *Mueller*, 9.vii.1848—MEL!

Of unknown introduction but, possibly introduced on the fleeces and coats of domestic animals.

Erodium cicutarium (L.) L'Her. ex Ait.

(F.A. I, 298. "A very common weed in Europe and temperate Asia, and found in many other parts of the world, in many cases introduced, as in several or perhaps all of the Australian localities, but too widely spread now to be omitted from the Flora, even if it be not really indigenous".)

Murray R., *Mueller*, s.d. (c. 1850); nr Spencer's Gulf, *Mueller*, s.d. (c. 1850)—MEL!

Evidently introduced very early and spread widely, probably by being attached to the fleece and coats of domestic animals.

GERANIACEAE (OXALIDACEAE)

**Oxalis pes-caprae* L. See page 124.

LEGUMINOSAE

Medicago denticulata Willd. (*M. polymorpha* var. *vulgaris* (Benth.) Shinners).

(F.A. II, 186. "Waste places, Queensland, N.S. Wales, Victoria and S. Australia".)

R. Torrens, before Lofty Ra., *Mueller*, 28.xii.1848; Pt Lincoln, *Wilhelmi*, s.d.—MEL!

Probably introduced inadvertently in sheep's fleeces by the earliest settlers. The basis for Bentham citing "waste places" is not known. McEwin (1847) noted that a *Medicago* was common in some situations at that time.

Medicago sativa L.

(F.A. II, 186. "Rocky pastures, Victoria and South Australia".)

North Adelaide, *Mueller*, 6.ii.1848—MEL!

It was recorded as growing in the Old Botanic Gardens in 1841 (Bailey, 1841), but Stevenson (1839a) was able to give instructions as to the correct time to sow it, which implies that he had already had local experience with the plant. The significance of Bentham's "rocky pastures" is not known.

Melilotus parviflora Desf. (*M. indica* (L.) All.)

(F.A. II, 186. "In South Australia".)

Crystal Brook, *Mueller*, x.?; Holdfast Bay, *Mueller*, ii.?, frequent—MEL!

Originally identified as *M. officinalis* by Mueller. Probably introduced as a fodder plant (Schomburgk, 1879), being confused with *M. officinalis* which was both a useful fodder in some parts of England (Sinclair, 1815) and a contaminant of harvested wheat (Loudon, 1835).

Trifolium agrarium L. (*T. campestre* Schreb.)

(F.A. II, 186. "In South Australia".)

No specimen was located. It was noted as growing at Beaudesert in 1858 (Anon., 1858). This location is unknown but the context indicates that it was in South Australia. The earliest collection located was a specimen collected by Tepper at Clarendon in 1881 (MEL!). That specimen is annotated "wild in fields, roadsides etc". This species was commonly grown in British pastures (Loudon, 1835).

Trifolium repens L.

(F.A. II, 186. "In South Australia".)

Chain of Ponds, *Mueller*, s.d. (c. 1849)—MEL!

According to an early report (Anon., 1859), this plant was introduced in two ways. It was sown by the earliest settlers at Glenelg (Holdfast Bay), as noted also by Capper (1838), and it was introduced in contaminated wheat from Van Diemen's Land.

Lotus corniculatus L.

(F.A. II, 188. Native species. "Near Bethanie, *F. Mueller*".)

The cited specimen was not located at MEL. The citation may have been based on the record of Schlechtendal (1847) of a specimen *L. corniculatus* var. *vulgaris* collected by Behr in 1844-45 in dried out creekbeds near Bethany. The status of this species is problematical as there seem to be both native and introduced forms (Burbidge and Gray, 1970). Also Eichler (1965) noted that there could be confusion between this species and *L. pendunculatus* Cav. If the determination was correct it is likely that the specimen came from cultivation, as that species is not established in that area even today, being too dry during summer.

Lotus tetragonolobus L.

(F.A. II, 188. ". . . a native of Southern Europe, has been introduced as a weed of cultivation in the Bugle Range, S. Australia, *F. Mueller*".)

Bugle Ra., *Mueller*, ix.1850, sub-spontaneous—MEL!

No specimen from S.A. is known from AD or ADW and it was not recorded by Black (1948). Mueller's specimen may have been from a garden, although it had been recommended as a potential fodder in England, having already been used for this purpose in the south of France (Loudon, 1835).

Vicia sativa L. var. *segetalis* Ser. (*V. sativa* L.)

(F.A. II, 241. "Naturalized, especially about Adelaide in South Australia".)

On plains betw. Adelaide and Gawler, *Mueller*, ix.?; South Australia, *s.l.*, s.d.—MEL!

Introduced early and grown as a fodder (Anon., 1843a). Whilst *V. sativa* var. *segetalis* is a synonym of *V. angustifolia* L. the cited specimens are, in fact, *V. sativa.*

Vicia hirsuta (L.) S.F. Gray

(F.A. II, 241. ". . . naturalized, especially about Adelaide in South Australia".)

Bugle Ra., *Mueller*, Spring 1850, spontaneous in cornfields—MEL!

Confined even now to pockets of the Adelaide Hills. Of uncertain introduction.

ROSACEAE

Rosa rubiginosa L.

(F.A. II, 432. ". . . is said to have established itself, apparently wild, in South Australia".)

Torrens R., nr Chain of Ponds, *Mueller*, iii.?—MEL!

This plant was introduced as an ornamental before 1839 (Stevenson, 1839). Five specimens were growing in the old Botanic Gardens at the end of 1841 (CSO, 1842). It appeared in nurserymen's catalogues e.g. McEwin, 1843; Bailey, 1845. No other evidence was found to support Bentham's statement as to its establishment as apparently wild at that time. The first references to it being weedy were much later (e.g. Anon., 1892; Anon., 1894).

Alchemilla arvensis Scop. (*Aphanes arvensis* L.)

(F.A. II, 432. ". . . in some, if not all, the Australian stations, very probably introduced from Europe". "Mountain pastures, Rivoli Bay, *F. Mueller*".)

A specimen—Kaiserstuhl, *Mueller*, ix.1848, MEL! has been determined by Rothmaler as a native species *A. australiana* Rothm. No specimen was found from Rivoli Bay. Black's (1909) citation of "near Gawler and Beachport" was presumably based on Bentham's locations. There are no specimens in the Black herbarium at AD although there are Tate and Tepper collections from as early as 1879 (AD!). However, if Rothmaler's taxonomic subdivision is not accepted, and the local material is considered identical to that in Europe, I have no explanation for its introduction other than as a contaminant of pasture seed.

HALORAGEAE (CERATOPHYLLACEAE)

Ceratophyllum demersum L.

(F.A. II, 491. Native. "Murray River, *F. Mueller*".)

Murray R. S.A., *Mueller*, ii.?; Murray R., *Mueller*, iv.?—MEL!

The second specimen may not have been from South Australia, although in April 1848 Mueller did collect along the lower Murray River and lakes.

An aquatic plant originating in the Old World that was most unlikely to have been intentionally introduced. It probably arrived attached to water birds. Its arrival could well have pre-dated European contact.

LYTHRARIEAE (LYTHRACEAE)

Lythrum hyssopifolium L.

(F.A. III, 299. Native. "St. Vincent's Gulf, etc. *F. Mueller* and others".)

There are no specimens at MEL that could have been cited as above. However, there are two separate folders of *L. hyssopifolium* which contain slips noting that the specimens were received back from Bentham with their annotations missing. It is possible that these two specimens were those cited by Bentham. Of uncertain introduction, but unlikely to have been introduced intentionally.

ONAGRARIEAE (ONAGRACEAE)

Oenothera biennis L. (*O. stricta* Ledeb. ex Link)

(F.A. III, 302. "A plant of N. American origin, long cultivated in gardens in Europe and other countries, and readily establishing itself in waste places on river banks, etc, and now said to be naturalized in many parts of N.S. Wales, Victoria and S. Australia".)

Betw. Mt. Lofty and the city, *Mueller*, 25.xii.1847; R. Torrens bed at Klemzig, *s.l.*, 27.ii.?; Enfield, *s.l.*, ix.?—MEL!

Probably a garden escape. *O. biennis* is the common evening primrose and it is suggested that *O. stricta* was introduced in error.

CUCURBITACEAE

Cucumis myriocarpus Naud.

(F.A. III, 318. ". . . is in F. Mueller's collection from the banks of the Torrens river in S. Australia, as an introduced plant".)

R. Torrens, *Mueller*, iii.1847—MEL!

This was cultivated in England under the name *C. prophetarum* Jacq. for the striped fruit which was regarded as a curiosity (Loudon, 1830). It seems likely that the species was an escape from cultivation.

FICOIDEAE (AIZOACEAE)

Mesembryanthemum aequilaterale Haw. (*Carpobrotus aequilaterus* (Haw.) N.E. Brown)

(F.A. III, 324. Native, also found on the coasts of Chile and California. "Murray river, Holdfast Bay, Salt plains on the W. side of Flinders Range, *F. Mueller*".)

The South Australian material at MEL was not located but older material from other states originally determined as *M. aequilaterale*, has been determined by S.T. Blake as *C. edulis* and *C. virescens*. Blake (1969) does not record any specimens of *C. aequilaterus* from South Australia.

Mesembryanthemum crystallinum L.

(F.A. III, 325. Native. "A common seacoast plant in S. Africa, found also on the

coasts of the Canary Islands, southern Europe, and California". "Holdfast Bay and Port Adelaide, *F. Mueller*".)

Holdfast Bay, *Mueller*, s.d.; betw. Holdfast Bay and Port Adelaide, *Mueller*, s.d.—MEL!

This was an ornamental (Loudon, 1830) which was available commercially in South Australia (e.g. Hackett, 1876). It was even recommended as a substitute for spinach (Heyne, 1871). No early record of its horticultural use was located but nevertheless its role as such may be assumed. There were no other records of it being established in South Australia until 1879 (Anon., 1879) so perhaps Mueller's specimens were from cultivation.

UMBELLIFERAE

Petroselinum sativum Hoffm. (*P. crispum* (Mill.) Nyman ex Hort. Kew)

(F.A. III, 336. "About Adelaide".)

At the Torrens, upstream from North Adelaide, *Mueller*, 23.i.1848—MEL!

Introduced very early and grown in vegetable gardens (Stevenson, 1839). This is only found as an occasional escape here and there (Black, 1952) and it does not seem to persist. From Mueller's location, his specimen could also have been a plant from cultivation.

Sium latifolium L.

(F.A. III, 336. "Cape Wilson and Lofty Range, *F. Mueller*".)

Mt. Lofty Ra., in creeks, *Mueller*, ii.1847—MEL!

Cape Wilson refers to a specimen collected at Wilson's Promontory, Victoria, in 1853. This is a difficult species which has caused much confusion (e.g. Black, 1909, 1926, 1952), as it is not certain whether this taxon is identical to the European *S. latifolium* or whether it is a native taxon.

Pastinaca sativa L.

(F.A. III, 336. "Near Adelaide, *F. Mueller*".)

Torrens R., *Mueller*, xi.1849—MEL!

The label on this specimen is of an unusual design which may indicate that the collection was of peculiar origin, e.g. a garden specimen. This species was also introduced as a vegetable very early (Stevenson, 1839) and it rarely escapes. Specimens have been collected four times this century from Millicent and once from the Hindmarsh Valley (AD!). One sheet at Adelaide (AD97618271) was annotated by Black thus: "I have never seen this plant wild. 12/3/17. Yes, at Millicent. 5/12/17". This plant is but adventive, persisting for short periods after cultivation.

Coriandrum sativum L.

(F.A. III, 336. "Near Adelaide".)

Nr Bethanien, *Mueller*, s.d.; gardens around Adelaide, *Mueller*, xii.1851—MEL!

The second specimen is very poor and may be misidentified. The species has never been collected outside gardens and, in my opinion was, and is, merely a garden herb. It is not part of the naturalised flora.

Daucus carota L.

(F.A. III, 337. ". . . more or less established in waste places near settlements in Victoria and South Australia".)

Third Ck, *Mueller*, i.?; Tanunda Ck, *Mueller*, iii.1852—MEL!

The carrot was an early introduction to vegetable gardens (Stevenson, 1839) and is now found wild occasionally in the south-east of this State. Mueller's specimens were likely to have been from or near market gardens. However, it was sown in England in pastures (Loudon, 1835).

RUBIACEAE

Galium aparine L. (*G. tenerum* Schleicher ex Grud.)

(F.A. III, 447. ". . . probably introduced". "Mount Gambier, *F. Mueller*".)

Towards R. Murray, *Mueller*, 6.x.1848; Mt Gambier, Limestone Caves, *Mueller*, i.1857—MEL!

The first specimen was also seen by Bentham but its location was omitted. A weed of cultivation probably accidentally introduced.

DIPSACEAE (DIPSACACEAE)

**Scabiosa maritima* L. (*S. atropurpurea* L.) See page 122.

COMPOSITAE

Centaurea melitensis L.

(F.A. III, 458. "A native of the Mediterranean region . . . very abundant in various parts of Queensland, N.S. Wales, Victoria, Tasmania, and S. Australia".)

On plains (parklands?) of city of Adelaide, *Mueller*, iv.?; urban Adelaide, *Mueller*, xi.1848; on road betw. Port Adelaide and Hahndorf, *Blandowski*, 1850—MEL!

Whilst this species was recorded as an ornamental in Britain (Loudon, 1830), no local evidence for this use was found. According to Schomburgk (1879) it was introduced about 1844 but no evidence supporting this contention was located.

Centaurea solstitialis L.

(F.A. III, 458. "S. Australia, *Herb. F. Mueller*".)

Around urban Adelaide, *Mueller*, xi.1848—MEL!

The specimen upon which Bentham's citation was based was misidentified; in fact, it was *C. melitensis. C. solstitialis* was not definitely recorded in South Australia until 1892 (MEL!).

Carthamus tinctorius L.

(F.A. III, 458. "Near Adelaide, in the neighbourhood of gardens".)

Big Gumtree Ck, *Mueller*, x.1851 (2 specimens)—MEL!

The location is not known. It must have been a local name of no official standing. This plant would have been introduced intentionally as a dye plant, known at that time as bastard saffron (Loudon, 1835), although no very early local records could be located. However, even now it is not a naturalised plant, persisting for only a short period after cultivation.

Onopordon acanthium L.

(F.A. III, 458. "Victoria and South Australia".)

South Australia, *Mueller*, 1848; By creek, *s.l.* (*Mueller*?) 3.ii.1848—MEL!

This has always been a rare plant in South Australia (e.g. annotation to AD97642230)

and has been confused in the past with *Cirsium vulgare* and *Silybum marianum* which have both been called "Scotch" thistles at various times. It has also been confused with *O. acaulon* (AD!). However, the cited specimens appear to me to be yet another thistle which I do not recognise.

**Onopordon acaulon* L. See page 123.

**Cirsium vulgare* (Savi) Ten. See page 123.

**Silybum marianum* (L.) Gaertn. See page 97.

Cynara cardunculus L. var. *scolymus* (L.) Benth. (*C. scolymus* L.)

(F.A. III, 459. "Near Adelaide".)

On road to Mt. Lofty, *Mueller*, xii.1847—MEL!

Both *C. cardunculus* and *C. scolymus* were very early introductions (Stevenson, 1839, 1839a). The latter has never become established outside cultivation. *C. cardunculus*, however, established itself (Anon., 1881) and went on to become a major weed particularly of the Adelaide Plains, the mid-North and adjacent areas. In the older literature the names *C. scolymus* and *C. cardunculus* were often interchanged erroneously (e.g. Schomburgk, 1879).

Adenostemma viscosum Forst.

(F.A. III, 462. "Entrance to the Murray river, *Wilhelmi*. Probably introduced".)

Towards the entrance, Murray R., *Wilhelmi*, 1849; Murray, *Mueller*, s.d.—MEL!

Apparently a casual introduction from eastern Australia or some other sub-tropical location that failed to persist. It has never been collected from South Australia since.

Erigeron linifolius Willd. (*Conyza bonariensis* (L.) Cronq.)

(F.A. III, 495. Common tropical weed. "Near Adelaide, and other places about St. Vincent's Gulf, *Behr*, *F. Mueller*, and others".)

St Vincent's Gulf, *Behr*, 1848; R. Torrens, *Mueller*, 18.i.1848; R. Torrens, nr Nth. Adelaide, *s.l.*, 23.i.1848; Tanunda, *Mueller*, 1.iii.1848; around Adelaide, *Mueller*, vii.1848; Gleeville, Mt Lofty Ra., *Mueller*, v.1849; St Vincent's Gulf, *Mueller*, 1851—MEL!

"Gleeville" was the property of Sir Samuel Davenport at Beaumont in the foothills of the Mt. Lofty Ranges. Bentham noted that some specimens may belong to *E. albidus* (syn. *C. albidus*). A very common weed found around settlements and probably introduced accidentally and very early.

Anthemis cotula L.

(F.A. III, 547. "N.S. Wales, S. Australia and W. Australia".)

Around urban Adelaide in waste places, *Mueller*, xi.1848—MEL!

The next specimen that was located was from Clarendon in 1881 (MEL!). It is not a common plant even now although in recent times it has been found more frequently in lawns. Attention has already been drawn to the possibility that this is really *A. arvensis* L. (Robertson, 1957; Kloot, 1980). The synonym *Maruta cotula* was used erroneously by Schomburgk for *Dittrichia graveolens* (L.) W. Greuter (Kloot, 1980).

Cotula coronopifolia L.

(F.A. III, 549. Native. "Near Adelaide and Lofty Range, *F. Mueller*; Kangaroo Island, *Waterhouse*".)

R. Torrens towards Lofty, *Mueller*, 27.xii.1847; Kensington, *Mueller*, 28.i.1848; urban Adelaide, *Mueller*, 28.i.1848—MEL!

Waterhouse's specimen was not located. This species has been discussed above on page 97.

Cryptostemma calendulacea R. Br. (*Arctotheca calendula* (L.) Levyns)

(F.A. III, 675. ". . . may have been introduced into Australia from the Cape". "Very common on roadsides about Adelaide, *F. Mueller*".)

Frequent in places about Adelaide, *Mueller*, 1848; Gawlertown, *Mueller*, ix.1848; betw. Pt Adelaide and Hahndorf, *Blandowski*, 22.ix.1849; Adelaide, *Blandowski*, 1850—MEL!

According to A. Molineux (1879) this plant first appeared on the banks of the Torrens, 300 yd (approx. 270m) above the first dam in 1841. Bailey (1879) also recalled that it had been introduced into Adelaide in 1840 or 1841 and soon had covered the whole of the Adelaide Plains.

According to another report two years later (Anon., 1882) it had been introduced about 38 years earlier from the Cape as a fodder plant. By 1862 (Anon., 1862) it was recorded as a common plant in the parklands of Adelaide.

Calendula officinalis L.

(F.A. III, 675. ". . . introduced about Adelaide, *Herb. F. Mueller*".)

Torrens R. nr Adelaide, *Mueller*, i.1848; Holdfast Bay, *Mueller*, 30.i.1848; s.l., *Mueller*, s.d. det. by Sonder in 1851—MEL!

The third specimen would have been collected by Mueller in South Australia but the locality is not known. The species was introduced as an ornamental and was being grown in the old Botanic Gardens in 1841 (Bailey, 1841). A garden escape.

Calendula arvensis L.

(F.A. III, 675. "A single specimen from Adelaide in Mueller's herbarium.")

Urban Adelaide, *Mueller*, vii.1848—MEL!

Another garden escape which is now much more widespread in South Australia than the previous species.

Hypochoeris glabra L.

(F.A. III, 677. Native. "Common, *F. Mueller* and others".)

Nr R. Torrens, *Mueller*, 28.xii.1847; nr city of Adelaide, *Mueller*, 28.xii.1847; Adelaide, *Mueller*, 20.vii.1848; betw. Pt Adelaide and Hahndorf, *Blandowski*, 22.ix.1849—MEL!

A common weedy plant, probably introduced accidentally.

Picris hieracioides L.

(F.A. III, 678. ". . . may be introduced". "Port Lincoln, *R. Brown, Wilhelmi*; Murray river to St. Vincent's Gulf, *F. Mueller* and others; Kangaroo Island, *Waterhouse*".)

According to Dr. H.W. Lack (pers. comm.) the material cited by Bentham is referable to *P. squarrosa* Steetz, or possibly a new taxon, both of which are endemic.

Sonchus oleraceus L. (includes *S. asper* (L.) Hill)

(F.A. III, 679. Introduced. "Mount Gambier, Bugle Range, Torrens river, etc., *F. Mueller*; towards Spencer's Gulf, *Waterhouse*".)

Adelaide, frequent, *Mueller*, 5.iii.1848; Gawler R. nr. Benthanien, *Mueller*, iii.1848; Gleeville, *Mueller*, 1849; Bugle Ra., *Mueller*, iv.1850; Tanunda, *Mueller*, s.d.; towards Spencer's Gulf, *Warburton*, s.d.—MEL!

This was a very common weed that was introduced early. McEwin (1847) noted it as one of the most troublesome weeds, which grew in "incredible quantities" on newly broken ground, and grew tall and rank if allowed.

Two specimens of *S. asper* as follows:

Gawler, *Mueller*, s.d.; Mt Gambier, *s.l.*, s.d.—MEL!

In *Sonchus* there are native taxa which are difficult to separate from introduced material (see Eichler, 1965; Willis, 1972).

Cichorium intybus L.

(F.A. III, 680. "S. Australia, *F. Mueller*".)

Gawler R. and Tanunda, *Mueller*, iii.1848—MEL!

Sown by the first settlers as a fodder species (Capper, 1838) and grown in gardens as a substitute for coffee (Stevenson, 1839). An escape from cultivation, highly palatable to stock and only becoming a problem on roadsides and other ungrazed places. Also see *Centaurea cyanus* on page 96.

PRIMULACEAE

Anagallis arvensis L.

(F.A. IV, 270. Introduced. ". . . more or less established in N.S. Wales, Victoria, Tasmania, S. Australia, and W. Australia".)

On road to Mt Lofty Ra., *Mueller*, xi.1848; blue form-Hake's (Hack's) place, *Mueller*, xi.1848; Kangaroo Is., *Waterhouse*, s.d.; Hake's (Hack's) place, *Mueller*, xii.1848; Other specimens annotated "in crops" and "half wild at St. Vincent's Gulf"—MEL!

An early garden plant (Anon., 1859) but no contemporary records were located.

GENTIANEAE (GENTIANACEAE)

Erythrea australis R. Br. (*Centaurium minus* Gars. & *C. spicatum* (L.) Fritsch.)

(F.A. IV, 371. Native plant almost identical to the European *E. spicata*. "South coast, *R. Brown*; round St. Vincent's Gulf and Torrens river, *F. Mueller*; Spencer's Gulf, *Warburton*".)

C. minus Gars.

Gawler Town, *Mueller*, xi.1848; St Vincent's Gulf, *Mueller*, s.d.—MEL!

C. spicatum (L.) Fritsch.

St Vincent's Gulf, *Mueller*, s.d.; towards Spencer's Gulf, *Warburton*, s.d.—MEL!

The status of the genus in Australia is obscure particularly as *C. spicatum* is very widespread, although of Eurasian origin, and may have been present in southern Australia before European settlement. *C. minus* under the name *Erythraea centaurium* was a highly regarded medicinal plant. One sheet at MEL! is annotated "A most valuable medicine".

BORAGINEAE (BORAGINACEAE)

Borago officinalis L.

(F.A. IV, 384. "About Adelaide in S. Australia".)

About Adelaide, *Mueller*, xi.1849; Pt Adelaide, *Blandowski*, 1850—MEL!

These two specimens are identical and are annotated in Mueller's writing "*Borago* sp. nov." and later "*Halgania* sp. nov." Thus, although *Borago officinalis* was an early introduction to South Australia as a herb grown in gardens, Bentham's citation is based on the misidentification of a native *Halgania*. *B. officinalis* has never been recorded as a garden escape in this State.

Anchusa officinalis L.

(F.A. IV, 385. "S. Australia".)

St Vincent's Gulf, *s.l.*, s.d. det. by Mueller—MEL!

A later hand has annotated the sheet indicating that it could be *A. capensis* Thunb. *A. officinalis* is otherwise not known from South Australia. *A. capensis* is known as a garden escape (Black 1912). It was available to the Australian trade at least as early as 1843 (Anon., 1843) and was being sold in Adelaide in 1845 (Bailey, 1845).

Lithospermum arvense L. (*Buglossoides arvensis* (L.) Johnston).

(F.A. IV, 385. "Established in several localities in Queensland, Victoria, Tasmania and S. Australia . . .".)

Clare village, *Mueller*, xi.1851—MEL!

Although no contemporary records were located, this species was noted as being common in neglected suburban gardens around Adelaide (Anon., 1875) from which I infer that it had been grown there earlier. It is possible that Mueller's specimen came from a garden.

Heliotropium curassavicum L.

(F.A. IV, 393. Native. "Murray river, *F. Mueller*".)

Lagoons nr R. Murray, *Stuart*, ii.1848; fields nr R. Murray at Moorundie, *Mueller*, 1849; R. Murray, *Mueller*, i.1850; shady beds, R. Murray, rare, *Mueller*, ii.1851—MEL!

Apparently a native of the Americas (Brummitt, 1972) but of unknown introduction to South Australia. Its arrival may have preceded European contact although it should be noted that it was not collected by Brown.

Heliotropium europaeum L.

(F.A. IV, 394. Native. "Head of Spencer's Gulf; *R. Brown*; in the interior, *McDouall Stuart*".)

These specimens were not seen but Benthan notes that Brown's specimens had a different aspect. This species was discussed on page 94.

CONVOLVULACEAE

**Convolvulus sepium* L. (*Calystegia sepium* (L.) R. Br.) See page 122.

SOLANEAE (SOLANACEAE)

Solanum nigrum L.

(F.A. IV, 446. "probably in some of the Australian localities, introduced with cultivation." "Lofty Range, *F. Mueller*; Kangaroo Island, *Waterhouse*".)

Third Ck, *Mueller*, 10.i.1848; gullies in Mt Lofty Ra., *Mueller*, xi.?—MEL!

The first collection was mixed and consisted of *S. nigrum* and *S. opacum* A. Braun & Bouche. The name *S. nigrum* was used for a number of species, both native and introduced (Symon, 1981a) but the true *S. nigrum* is a native of Eurasia (Symon, *op. cit*). Of uncertain introduction, probably as a garden weed.

Physalis peruviana L.

(F.A. IV, 466. Introduced. "Near Adelaide, *Blandowsky*".)

Betw. Pt Adelaide and Hahndorf, on roadside, *Blandowski*, 22.ix.1849 (MEL 91267!); Sturt R., *s.l.*, xi.1849—MEL!

Symon (1981) has drawn attention to Bentham's citation for Sturt River in N. Australia being an error for the second specimen listed here. Introduced as a minor cultivated crop plant under the name of *P. edulis* and *P. frutescens* and growing in the old Botanic Garden in 1841 (Bailey, 1841; CSO, 1842).

A minor garden escape, it was noted as growing very freely and fruiting at Second Valley in 1850 (Yelland, 1970).

Datura tatula L. (*D. stramonium* L.)

(F.A. IV, 469. "An introduced weed".)

R. Torrens, nr North Adelaide, *Mueller*, 23.i.1848, MEL501745!; St Vincent's Gulf, *Mueller*, s.d., MEL501744!

A very early introduction. Bailey (1906) recalled children in Adelaide as early as 1839 eating of the plant and becoming ill. It is likely that this species was deliberately introduced by nurserymen, for Loudon (1830) indicated that it was cultivated in England at that time. Other species of *Datura* now naturalised in Australia are still grown in Europe as ornamentals (Moore, 1972). *Brugmansia fastuosa*, a synonym of *Datura metel* was recorded in early South Australian nurserymen's catalogues (McEwin, 1843; Bailey, 1845).

Nicotiana glauca Grah.

(F.A. IV, 469. "Escape from gardens".)

R. Torrens, sub-spontaneous, *Mueller*, xii.?—MEL!

This plant was introduced to Adelaide from Melbourne about 1847 by Mr. F.M. Dutton and one box was given to Bailey's Hackney Nurseries (Anon., 1894).

SCROPHULARINEAE (SCROPHULARIACEAE)

Verbascum blattaria L. (*V. thapsus* L.)

(F.A. IV, 473. Introduced. "N.S. Wales, Victoria and S. Australia".)

Brownhill Ck, *Mueller*, viii.?—MEL!

This specimen was identified as *V. blattaria β virgatum*. It was seen by Bentham but he recorded *V. virgatum* from Victoria only. Many species of the genus *Verbascum*, including those mentioned here, were grown in Britain as ornamentals (Loudon, 1830) but no local evidence was found.

Veronica peregrina L.

(F.A. IV, 511. Introduced. "Rocky River, *F. Mueller*", erroneously placed in Victoria.)

Rocky R., *Mueller*, x.1851—MEL!

Of unknown introduction.

VERBENACEAE

Verbena officinalis L.

(F.A. V, 36. Perhaps introduced into some localities. "Near Adelaide, *Blandowski*; towards Spencer's Gulf, *Warburton*".)

Third Ck, *Mueller*, 10.i.1848; betw. Pt Adelaide and Hahndorf, *Blandowski*, 22.ix.1849; towards Spencer's Gulf, *Warburton*, s.d.—MEL!

A native of Eurasia (Munir, 1981) previously considered native to Australia by all authorities. This species did have medicinal uses (Howes, 1974) which would have been a reason for its introduction. However, as Bentham notes the species was common on roadsides and waste places it could have been accidentally introduced. It is possible that its arrival in Australia preceded European settlement, and was an extension of its vast range in Eurasia where it is found as far south as the tropics. Recorded as growing on the banks of the River Torrens in 1837 (Backhouse, 1843), and collected by Behr in 1844-45 in rocky, damp places at Tanunda (Schlechtendal, 1847).

LABIATAE

Marrubium vulgare L.

(F.A. V, 73. "A roadside weed of European or Asiatic origin . . . and gathered by various collectors in N.S. Wales, Victoria and S. Australia".)

At Hake's (Hack's) place, *Mueller*, xii.1848 nr Spencer Gulf, *Mueller*, s.d.—MEL!

This species was used extensively for medicines and confectionery in the past (Bailey, 1943) and was being recommended to be grown more widely in South Australia for its medicinal properties as late as 1885 (Schomburgk, 1885). Yet it had been noted as densely overgrowing large spaces on the hills and in the dales of Bullaparinga (near Second Valley) as early as 1850 (Yelland, 1970). It was spread by catching in sheeps' fleeces.

Nepeta cataria L.

(F.A. V, 73. ". . . occurs in the neighbourhood of Adelaide".)

St Vincent's Gulf, *Mueller*, iii.1851—MEL!

A very rare plant that has been collected only twice in South Australia since Mueller's collection (AD!). Mueller's specimen may have been associated with a garden.

Rosmarinus officinalis L.

(F.A. V, 73. ". . . has been introduced into Hope Valley, Victoria, *F. Mueller*".)

Hope Valley, *Mueller*, viii.1848—MEL!

Bentham's citation is incorrect, the specimen being from South Australia. Introduced early (Stevenson, 1839) as a herb plant and used also for hedges. Not truly naturalised even now as it only occasionally persists or spreads slightly from cultivated plants. Probably Mueller's collection was of such a plant.

Mentha viridis L. (*M. spicata* L. emend. Huds.)

(F.A. V, 82. Introduced. "Borders of streams, Mount Lofty Range, *F. Mueller*".)

Mt Lofty Ra., *Mueller*, i.1848; borders of streams, Mt Lofty Ra., *Mueller*, i.1848—MEL!

A garden escape introduced to South Australia by 1843 (McEwin, 1843).

Prunella vulgaris L.

(F.A. V, 87. Native to Australia as well as northern temperate regions etc. "Torrens river, *F. Mueller*; Rapide Bay, *Malpas*".)

Nr Pt Adelaide and Rapide Bay, *Blandowski*, 1850—MEL!

Bentham's citation may be based on a misreading of the extant specimen or there may have been others that are now missing. This plant was used as a medicinal and ornamental in the past (Bailey, 1943) although no local evidence for these uses was found.

PLANTAGINEAE (PLANTAGINACEAE)

Plantago coronopus L.

(F.A. V, 138. ". . . probably introduced into Australia". Holdfast Bay, *F. Mueller*".)

Holdfast Bay, *Mueller*, xii.1851—MEL!

Although other species of *Plantago* were sown as pasture plants, *P. coronopus* was not. Probably an accidental introduction.

CHENOPODIACEAE

**Chenopodium murale* L. See page 122.

Atriplex patula L.

(F.A. V, 173. ". . . probably only of modern introduction in Australia." "Holdfast Bay and Gawler Ranges, *F. Mueller*".)

Gawler R. ("fluvii Gawleri"), *Mueller*, 15.iv.1848—MEL!

The specimen from Holdfast Bay was not located and as shown the reference to Gawler Ranges is an error. This plant is generally associated with seacoasts or swampy areas and is also known as a garden weed. It was probably introduced with ballast dumped in areas suited to the plant, or with garden materials.

POLYGONACEAE

Emex australis Steinh.

(F.A. V, 262. "perhaps introduced from thence" [South Africa]. "Near Adelaide and Holdfast Bay, *F. Mueller*".)

Holdfast Bay, *Mueller*, 30.i.1848; Nth Adelaide, on roadside, *Mueller*, vii.1848—MEL!

There is a persistent story that this plant was introduced, at least, to Western Australia by the first settlers in 1830 as a potential vegetable akin to spinach. This account arose from Turner's (1912) report but I am not aware of the basis of this story.

The most plausible explanation of its introduction to South Australia, is that it came in contaminated hay brought from the Cape Colony by Dr. Nash of Marino for his horses about 1840 (Anon., 1934). If the hay was fed out in the sandy country close to the coast, the *Emex* would have been introduced into a very congenial environment. From there it was carried northward to Holdfast Bay where, according to the same source, it was very thick in the 1850s. At that time Holdfast Bay was the main port from which people, animals and goods were despatched to many places, so the plant would have been spread far and wide.

Rumex crispus L.

(F.A. V, 263. Naturalised. "Barker town, *F. Mueller*".)

Mount Barker township, adventive, *Mueller*, ii.1850—MEL!

Probably introduced as a contaminant in garden seeds or implements.

Rumex acetosella L. (*R. angiocarpus* Murb.)

(F.A. V, 265. Introduced.)

R. Torrens, rare, *Mueller*, i.1847; about Adelaide, *Mueller*, s.d.—MEL!

Introduced very early as a garden vegetable (Stevenson, 1839a) but evidently it escaped soon afterwards, at least in the Mt Gambier area where it was already a problem by 1862 (Anon., 1862a).

Polygonum aviculare L.

(F.A. V, 267. ". . . probably introduced". "Near Adelaide, *F. Mueller*".)

Around Adelaide, *Mueller*, 28.xii.1847; on roads, waste places and cultivated land around Adelaide, *Mueller*, 14.i.1848—MEL!

The two labels are attached to one specimen which looks somewhat atypical. The taxonomy of this aggregate in Australia has been examined (J. Tideman, pers. comm.) and the name used here is doubtful. Mueller's note of January 1848 implies that it was widespread at that time. Probably introduced accidentally, as it had a bad reputation even earlier (Sinclair, 1815; Loudon, 1835).

EUPHORBIACEAE

**Ricinus communis* L. See page 123.

URTICACEAE

Urtica urens L.

(F.A. VI, 191. "A European weed now common near buildings in various parts of Victoria, Tasmania and S. Australia".)

Wheal Gawler, around buildings and sheds, *Mueller*, viii.1848—MEL!

Wheal Gawler was a mine above Glen Osmond. This weedy species was noted by Schomburgk (1879) as being imported from Tasmania in hay about 1840.

JUNCACEAE

Juncus bufonius L.

(F.A. VII, 127. Common in temperate parts of Globe. "St. Vincent's Gulf to Rivoli Bay, and the Murray, *F. Mueller, Behr*".)

N. Holland austr., *Mueller*, s.d.; Torrens R., *Mueller*, 28.xi.1847; Rivoli Bay, *Mueller*, 1848—MEL!

The taxonomy of this species is difficult, as it is not certain if only one species is involved. This plant is found widely throughout the world and its presence in Australia may have preceded European settlement.

GRAMINEAE

Panicum miliaceum L.

(F.A. VII, 488. ". . . in South Australia as an escape from cultivation".)

No specimens were located. Black (1909) recorded it as cultivated as fodder and spontaneous in moist places, but he did not have any specimens in his herbarium (AD). Later collections are very scattered and suggest that it may have been associated with discarded bird seed or that it was a contaminant of other crops. It is doubtful whether it is naturalised even now.

Polypogon monspeliensis (L.) Desf.

(F.A. VII, 546. ". . . perhaps . . . an introduced weed". "Holdfast Bay, *F. Mueller*".)

Holdfast Bay, *Mueller*, 1851 (2 specimens)—MEL!

A common weedy grass probably introduced accidentally, but as it is commonly found in wet areas, its movement by water birds must be considered a possibility.

Alopecurus geniculatus L.

(F.A.VII, 555. ". . . perhaps truly indigenous to Australia and New Zealand." "Spencer's and St. Vincent's Gulfs to the Murray, *F. Mueller*".)

Rocky R., *Mueller*, x.1851 (2 specimens); betw. Crystal Brook and Rocky R., *Mueller*, x.1851; R. Broughton, *Mueller*, x.1851 (2 specimens)—MEL!

A grass that is now more commonly found in the northern areas and less frequently in wetter areas. Of uncertain introduction, but it was recorded as fodder grass of wet areas in England (Sinclair, 1815).

Phalaris minor L.

(F.A. VII, 556. Perhaps introduced. "St. Vincent's Gulf, *Story*".)

Third Ck, *Mueller*, 10.i.1848 (2 specimens); Adelaide, roadsides and fields, *Mueller*, xi.1848—MEL!

According to annotations on sheets at MEL! it appears that some forms may have been introduced intentionally as cultivars, but others are weedy forms. The introductions could have been as misidentified, or as contaminants of *P. canariensis* which was grown widely, being highly regarded as horse fodder (Loudon, 1835).

Phalaris canariensis L.

(F.A. VII, 557. Introduced. "Naturalised on the seashores of Bremerhaven, *F. Mueller*".)

No specimen could be located at MEL, but many specimens collected from other places at other times and originally identified by Mueller as *P. canariensis* have since been correctly determined as *P. minor*. Furthermore, the locality is in doubt, as no such place is known in South Australia. Perhaps it was a European specimen. Introduced as a crop for bird seed and horse fodder.

Deschampsia caespitosa (L.) Beauv.

(F.A. VII, 587. Native. "Between Rivoli Bay and Mount Gambier, *F. Mueller*".)

Betw. Rivoli Bay and Mt Gambier, *Mueller*, s.d.—MEL!

A widespread grass, which may have been introduced prior to European settlement. It has never again been collected from Mueller's station. It is now found in the Hindmarsh Valley with a further record from an Adelaide suburb.

Avena fatua L.

(F.A. VII, 588. Introduced weed. "Now established as apparently wild in S. Australia . . . (*F. Mueller*)".)

Betw. Torrens and Pt Adelaide, *Blandowski*, 1851; Mt Lofty Ra., Kensington and Glen Osmond, *Mueller*, 30.xi.1851—MEL!

A cereal weed probably introduced with the original seed wheat being a common contaminant of harvested cereals in England (Loudon, 1835). By 1858, it was found on all cultivated land and was the "pre-eminent" weed of South Australia (Anon., 1858). The closely related *A. sterilis* was introduced as an ornamental grass before 1856 (Francis, 1859) but a more precise record could not be located.

Cynodon dactylon (L.) Pers.

(F.A. VII, 609. Native, but Bentham notes that Brown had suggested that it was introduced with cultivation. "St. Vincent's Gulf to the Murray, *F. Mueller* and others.")

City and Pt Adelaide, *Mueller*, 9.iii.1848; Adelaide, growing on roadsides, *Mueller*, iv.1848—MEL!

The status of this species is difficult but I feel that the forms found in the southern parts of the State are introduced. Originally imported as a fodder grass (Francis, 1959a) but heavily promoted as a turf grass (Schomburgk, 1870).

Koeleria phleoides Pers.

(F.A. VII, 639. ". . . may be introduced." "Adelaide and Torrens River, *F. Mueller*".)

Urban Adelaide, *Mueller*, s.d.; Torrens R., *Mueller*, s.d.—MEL!

See page 99.

Poa annua L.

(F.A. VII, 654. Introduced. Abundant in South Australia and elsewhere.)

Around Adelaide, *Mueller*, v.1848 (2 specimens) MEL!

See page 98.

Glyceria fluitans R. Br.

(F.A. VII, 657.)

In error for the native *G. australis* Hubbard. (See Eichler, 1965).

Briza minor L.

(F.A. VII, 660).

Probably of Mediterranean origin . . . of recent introduction to many parts of Australia." "Around St. Vincent's and Spencer's Gulfs, *F. Mueller*".)

Bethany, *Mueller*, 1848; Adelaide, *Mueller*, 1848; betw. Pt Adelaide and Hahndorf, *Blandowski*, 22.ix.1848; Hahndorf, *Blandowski*, s.d.; betw. Adelaide and Hahndorf, *s.l.*, ix.1849—MEL!

See page 98.

Briza maxima L.

(F.A. VII, 660. Introduced. Established in a few localities in South Australia and elsewhere.)

Echunga, *Mueller*, Spring 1848; Torrens R., *Mueller*, xi.1849—MEL!

See page 98.

Ceratochloa unioloides DC. (*Bromus unioloides* H.B. & K.)

(F.A. VII, 662. ". . . Naturalised in a few localities in . . . S. Australia . . .").

Torrens, *Mueller*, 1848; Torrens at Nth Adelaide, *Mueller*, 29.i.1848—MEL!

Introduced a number of times as a fodder plant (Anon., 1859; annotations to specimens collected at Mt Gambier in 1869, MEL!). McEwin (1847) noted that a "brome grass (*Bromus mollis*)" was common. It is not certain which species was intended. Mueller (1873) wrote that he had noted *B. sterilis* and *B. mollis*, as well as other *Bromus* spp., as introduced in 1847. These two names were used last century for *B. diandrus* Roth. and *B. hordeaceus* L. respectively. No specimens or any further literary references of this period were located to support Mueller's observation.

Festuca bromoides L. (*Vulpia bromoides* (L.) S.F. Gray).

(F.A. VII, 663. Native. "Round St. Vincent's Gulf, *F. Mueller*".)

Kensington, Adelaide, *Mueller*, 1848; Kensington, in fields, *Mueller*, xi.1848; Hahndorf, *Blandowski*, 1848; Pt Adelaide, *Blandowski*, 1850; Bethanien, *Herb. Mueller*, s.d.—MEL!

Common weedy species of unknown introduction. Although Bentham included *V. myuros* (L.) Gmel. within his species, all the cited material is in fact *V. bromoides*.

Festuca rigida Mert. & Koch (*Catapodium rigidum*) (L.) Hubbard).

(F.A. VII, 664. "Introduced from Europe and now common about Adelaide and Hopkins River, *F. Mueller*; Lake Bonney, *Mrs. Wehl*; Port Lincoln, *S.F. Browne*".)

Urban Adelaide, *Mueller*, 21.xi.1848; St Vincent's Gulf, *Mueller*, 1848; nr Mt Gambier, *Wall (? Wehl)*, s.d.; Pt Lincoln, *Browne*, 1875; Lake Bonney, *Mrs. Wehl*, s.d.—MEL!

The specimens from Lake Bonney and Port Lincoln are from a later period than this paper attempts to cover but have been included for completeness.

A weedy grass of unknown introduction, yet as late as 1874 it was introduced to the Adelaide Botanic Gardens (Schomburgk, 1875).

Lolium perenne L.

(F.A. VII, 666. Now naturalised in several localities in South Australia and elsewhere.)

South Australia, everywhere, *Mueller*, s.d.—MEL!

Presumably Mueller did not bother to collect any further specimens, yet it is likely that there would have been much variation in the forms present, even at that time. From Linneaus (1753) onward forms found in pastures were assigned to *L. perenne* and those from crops, to *L. temulentum*, yet it is likely that *L. rigidum* and probably *L. multiflorum* would have been present but not recognised (Kloot, unpubl. data).

L. temulentum L. (incl. *L. rigidum* Gaud.)

(F.A. VII, 667. Naturalised in South Australia and elsewhere and apparently more abundant than *L. perenne*.)

Third Ck, *Mueller*, 10.i.1848 (2 specimens, one awned, the other not); on the way to Mt Lofty Ra., *Mueller*, xi.1848 (unawned); Bugle Ra., in grain crops, *Mueller*, 4.xi.1848 (awned)—MEL!

See page 96.

L. temulentum var. *linicola* (Sond.) Benth. (*L. remotum* Schrank.)

(F.A. VII, 667. "Near Adelaide, *Blandowski*".)

St Vincent's Gulf, *Blandowski*, s.d.; Adelaide, ? *Blandowski*, s.d.; nr. Pt Adelaide, *Blandowski*, 1850—MEL!

These specimens are identical. They are difficult being too fine in their features to be *L. temulentum*. They also do not agree with *L. remotum* (syn. *L. linicola*) and I have tentatively identified them as *L. persicum*. Like *L. temulentum* this was probably a contaminant of seed grain but has failed to persist in Australia.

Hordeum murinum L. (*H. glaucum* Steud.)

(F.A. VII, 669. Introduced and now well established in South Australia and elsewhere.)

Around Adelaide, frequent in waste places and on roads, Mueller, xi.1848; Glen Osmond, on roads and around fields, Mueller, xi.1848—MEL!

Although in later years *H. leporinum* Link was erroneously included in *H. murinum* by Australian authors, during the period under review only *H. glaucum* seems to have been present in South Australia. Cocks *et al.* (1976) investigated the early history of this plant and concluded that it was an unintentional introduction from Europe, probably via the Cape Colony, as a contaminant of fodder or adhering to fleece.

Species excluded from the "*Flora Australiensis*"

Mueller collections

The following species although collected by Mueller were not recorded by Bentham in the *Flora Australiensis* for South Australia.

Papaver rhoeas L.

(F.A. I, 63. Recorded for Victoria but not South Australia.)

Adelaide, rare in cultivated fields, *Mueller*, xi.1849—MEL!

This specimen was seen by Bentham and as no Victorian specimen was found it is possible that the record for Victoria was an error. A popular ornamental in Britain (Loudon, 1830) but also known as a contaminant of cereal grain (Loudon, 1835). Uncommon even now in South Australia.

Scabiosa maritima L. (*S. atropurpurea* L.)

Entirely omitted from the *Flora Australiensis.*

Mt Lofty Range, spontaneous in places, *Mueller*, xii.1851—MEL!

This is an escaped garden plant which was introduced by 1843 (McEwin, 1843).

Convolvulus sepium L. (*Calystegia sepium* (L.) R. Br.)

(F.A. IV, 430. Recorded for other States but not for South Australia.)

Settlement of Adelaide, *Mueller*, i.1848; R. Torrens, *Mueller*, 23.i.1848—MEL!

The taxonomy of this species is difficult and Eichler (1965) has drawn attention to the different forms found here. It was grown as an ornamental (Loudon, 1830) but no local evidence from this period has been found.

Chenopodium murale L.

(F.A. V, 160. Recorded for Queensland, Victoria and Tasmania.)

Common about urban Adelaide, *Mueller*, vii.1848; Holdfast Bay, in gardens, *Mueller*, xii.?—MEL!

A common weed probably introduced accidentally very early. No earlier reference to it was located.

Other records

The following species were not recorded in the *Flora* nor were they known to have been collected by Mueller or the other collectors of that period, but nevertheless are believed to have been naturalised in South Australia.

Cirsium vulgare (Savi) Ten.

According to A. Molineux (1879) he first saw it close to the residence of the Governor of the Adelaide Gaol on the banks of the Torrens in 1841. By 1850, it had the reputation of being "an atrocious thistle, the curse of the Colony" (Yelland, 1970). This was the species erroneously called "Scotch" thistle and one of the species subject to the 1851 Thistle Act.

Onopordon acaulon L.

According to two reports, both unsigned but written by A. Molineux, who was a reliable observer, this species had been introduced as an ornamental by 1844 (Anon., 1891a), and had escaped into the Adelaide parklands by 1845 (Anon., 1897).

Silybum marianum (L.) Gaertn.

The other species for which the 1851 Thistle Act was introduced. This was discussed on page 97.

Ricinus communis L.

Pascoe (1901) recalled that castor oil plants were growing on a rubbish heap on the corner of King William and Currie Streets, Adelaide, during the 1840s. It had been introduced to the old Botanic Garden before 1841 (Bailey, 1841) and was being heavily promoted for its oil production by 1843 (Stevenson, 1843).

G.W. Francis

George Francis, first Director of the Adelaide Botanic Gardens, was a great admirer of Sir William Hooker of Kew. Francis dedicated his first publication to him and some years later engaged in correspondence with Hooker to seek his assistance in developing his Botanic Gardens and the associated botanical museum (Best, 1966). In a letter dated 26 May 1855, Francis (1855) added a postscript on the subject of introduced plants. This is reproduced verbatim from Best (*op. cit.*).

"P.S. Some British plants are certainly native here, as poa annua, polygonum aviculare-sonchus oleraceus—Hevularia glabra—Malva sylvestris and two or three Chenopodiums—others now common but introduced as Escholzia californica, Medicago lupulina—Melilotus leucantha—Calendunia grandiflora—Oxalis cernua—Papaver rheias . . ."

Francis' observations are not supported by any extant collections. However, *Poa annua*, *Polygonum aviculare* and *Sonchus oleraceus* had been collected by Mueller some years earlier. These species have been discussed already. *Hevularia glabra* (sic) is an error and the species intended is not known. A suggestion that this may be a mistranscription of *Herniaria glabra* seems improbable because this species has never been recorded from South Australia, but Francis may have misidentified one or more of the other Caryophyllaceae that were present at the time. *Malva sylvestris* is not known from South Australia, but *M. parviflora* was collected by Mueller about Adelaide. *Chenopodium murale* was collected by Mueller in South Australia but omitted for South Australia by Bentham (1870), as mentioned earlier. No records from that period of other alien species of *Chenopodium* have been located. *Eschscholtzia californica* has always been a rare plant outside gardens in South Australia. Perhaps another poppy was intended but there is no indication from collections what it might have been.

Medicago lupulina has always been rare and *M. polymorpha* var. *vulgaris* Shinners, is more likely to have been meant, the latter being common in South Australia and sometimes confused with the former, which was more common in Britain. *Melilotus leucantha* is a synonym for *M. alba* Medik. but the first record that has been located for this plant in South Australia is much later (Anon., 1891), and it has always been rare. *M. indica*, on the other hand was collected by Mueller and was listed above. *Calendunia grandiflora* is probably a mistranscription of *Calendula grandiflora* which is a horticultural name for a cultivar of *C. officinalis*, which was present at that time and collected by Mueller.

Oxalis cernua L. (*O. pes-caprae* L.)

This species was introduced as an ornamental before 1841 (Bailey, 1841), but escaped and became a very serious weed. It was not collected by Mueller which suggests that it may still have been confined to gardens at that stage. Its mention by Francis implies that it had escaped and had become a troublesome weed between 1850 and 1855. No specimens from this period were located.

Conclusion

By 1855, nearly twenty years after the foundation of the Colony, there were 114 alien species recorded as naturalised in South Australia, according to the evidence presented here. This is an over-estimate because it includes *Lychnis githago*, *Lotus tetragonolobus*, *Petroselinum crispum*, *Pastinaca sativa*, *Coriandrum sativum*, *Carthamus tinctorius*, *Onopordon acanthium*, *Adenostemma viscosum*, *Borago officinalis*, *Nepeta cataria*, *Rosmarinus officinalis*, *Panicum miliaceum* and *Phalaris canariensis* which have never really become established. Furthermore, there are other species, whose status during this early stage is not really clear, although in later years they undoubtedly became established e.g. *Mesembryanthemum crystallinum*, *Buglossoides arvensis*.

Of the 101 species that I have taken to be naturalised by 1855, 90 were from Europe, 6 were introduced from South Africa, 2 arrived from North America and 3 were from South America. Nine European and one South African species were not included in the "*Flora Australiensis*". All the extra-European species with the exception of *Cotula coronopifolia*, *Arctotheca calendula* and *Emex australis* probably reached Australia via Europe, having been previously introduced there as ornamentals e.g. *Oxalis pes-caprae*, *Oenothera stricta*.

Of the total, 55 species are either known to have been imported intentionally, or there is a very strong case based on available evidence for deliberate introduction. Others are suspected but no firm evidence yet has been found.

The rate of introduction, or more correctly, naturalisation, may be examined. By 1855, as shown in this paper, 101 species were naturalised. Black (1909) included 368 plants as naturalised in South Australia at that time. At present, the number is about double that of Black's figure (Kloot, unpubl. data). Thus during the periods 1836-1855, 1855-1909 and 1909 to the present, the increase in naturalised species has been about the same, viz. an average of 5-6 species per year, a figure that approximates the equivalent figure for Victoria (Ross, 1976). However, it is somewhat higher than the figure for Queensland (Everist, 1959) which is about 4 per year. The explanation may be that the historical, social and economic links of the settlers of sub-tropical Queensland were originally with temperate regions and the species introduced, either intentionally or accidentally, from such sources are less likely to succeed in such a different ecosystem.

Early records of alien flora in South Australia are probably better than for most other States, because of the fortunate circumstances of a concentrated period of collecting shortly after settlement. Brown's activities at Sydney between 1802 and 1805 may be comparable. Further studies of the development of the South Australian alien flora are in preparation.

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References

Anon. (1843). "Catalogue of plants cultivated at Camden 1843".
Anon. (1843a). Agricultural calendar—March in T.Y. Cotter "The South Australian Almanack and Adelaide and Colonial Directory for 1844". (MacDougall: Adelaide).
Anon. (1858). *Farm and Garden* 1:76.
Anon. (1859). *Farm and Garden* 1:207.
Anon. (1862). *Farm and Garden* 4:216.
Anon. (1862a). *Farm and Garden* 5:21.
Anon. (1875). *Garden and Field* 1:65.
Anon. (1878). *Garden and Field* 3:142.
Anon. (1879). *Garden and Field* 4:41.
Anon. (1881). *Garden and Field* 7:12, 116.
Anon. (1882). *Garden and Field* 7:116.
Anon. (1891). *J. Bur. Agric. S.A.* 4:12.
Anon. (1891a). *J. Bur. Agric. S.A.* 4:92.
Anon. (1892). *J. Bur. Agric. S.A.* 5:51.
Anon. (1894). *J. Bur. Agric. S.A.* 7:211.
Anon. (1897). *J. Agric. and Indus. S.A.* 1:98.
Anon. (1934). *The Advertiser.* Adelaide, December 19, 1934.
Backhouse, J. (1843). "A Narrative of a Visit to the Australian Colonies." (Hamilton: London).
Bailey, F.M. (1879). On some of the introduced plants of Queensland. *Proc. Linn. Soc. NSW* 4:26-36.
Bailey, F.M. (1906). "Weeds and Suspected Poisonous Plants of Queensland." (Pole: Brisbane).
Bailey, J. (1841). Plants flowering in the Botanic Gardens, June 1841. *S.A. Magazine* 1:11.
Bailey, J. (1845). Catalogue of Plants cultivated in and for sale at the Hackney Nursery, Adelaide, 1845. *The Adelaide Observer*, May 3, 1845.
Bailey, L.H. (1943). "The Standard Cyclopedia of Horticulture". 3 vols. (Macmillan: New York).
Baldwin, B.S. (1967). Letters of Samuel Davenport. Part II: February-September 1844. *South Australiana* 6:71-116.
Barker, W.R. (1977). The species of *Malva* L. and *Lavatera* L. (Malvaceae) naturalised in South Australia. *J. Adelaide Bot. Gard.* 1:107-114.
Behr, H.H. (1847). Südaustralische Pflanzen I. Ueber die Verhaltnisse der südaustralischen Flora im Allgemeinen. *Linnaea* 20:545-558.
Behr, H.H. (1851). On the character of the South Australian flora in general. *Hooker's J. Bot. Kew Gard. Misc.* 3:129-134.
Behr, H.H. (1891). Botanical reminiscences. *Zoe* 2:2-6.

Bentham, G. (1863). "Flora Australiensis", vol. 1. (Reeve: Ashford).
Bentham, G. (1864). "Flora Australiensis", vol. 2. (Reeve: Ashford).
Bentham, G. (1867). "Flora Australiensis", vol. 3. (Reeve: Ashford).
Bentham, G. (1868). "Flora Australiensis", vol. 4. (Reeve: London).
Bentham, G. (1870). "Flora Australiensis", vol. 5. (Reeve: Ashford).
Bentham, G. (1873). "Flora Australiensis", vol. 6. (Reeve: London).
Bentham, G. (1878). "Flora Australiensis", vol. 7. (Reeve: Ashford).
Best, B.J. (1966). "The Life and Works of George William Francis". (Adelaide).
Black, J.M. (1909). "The Naturalised Flora of South Australia". (Adelaide).
Black, J.M. (1912). Additions to the flora of South Australia. *Trans. & Proc. Royal Soc. S. Austral.* 36:21-25.
Black, J.M. (1926). "Flora of South Australia", vol. 3. 1st Ed. (Gov. Printer: Adelaide).
Black, J.M. (1948). "Flora of South Australia", vol. 2. 2nd Ed. (Gov. Printer: Adelaide).
Black, J.M. (1952). "Flora of South Australia", vol. 3. 2nd Ed. (Gov. Printer: Adelaide).
Blake, S.T. (1969). A revision of *Carpobrotus* and *Sarcozona* in Australia, genera allied to *Mesembryanthemum* (Aizoaceae). *Contr. Qld. Herb.* 7:1-65.
Britten, J. (1906). Introduced plants at Sydney, 1802-4. *J. Bot. Lond.* 44:234-235.
Brown, R. (1814). General remarks, geographical and systematical, on the Botany of Terra Australis in M. Flinders, "A voyage to Terra Australis", vol. 2. pp. 533-613. (Nichol: London).
Brummitt, R.K. (1972). *Heliotropium* in T.G. Tutin *et al.* (ed.) "Flora Europaea". vol. 3. (University Press: Cambridge).
Burbidge, N.T. and Gray, M. (1970). "Flora of the A.C.T.". (ANU Press: Canberra)
Capper, H. (1838). "South Australia". (Tyas: London).
Carolin, R.C. (1964). The genus *Geranium* L. in the south-western Pacific area. *Proc. Linn. Soc. N.S.W.* 89:326-361.
Carolin, R.C. and Hewson, H.J. (1981). Cruciferae in J.P. Jessop (ed.) "Flora of Central Australia". (Reed: Sydney).
Churchill, D.M., Muir, T.B. and Sinkora, D.M. (1978). The published works of Ferdinand J.H. Mueller (1825-1896). *Muelleria* 4:1-120.
Cocks, P.S., Boyce, K.G. and Kloot, P.M. (1976). The *Hordeum murinum* complex in Australia. *Aust. J. Bot.* 24:651-662.
CSO. (1842). Return of Trees and Shrubs in the Botanic Garden. Colonial Secretary's Office 5/1842.
Curtis, W.M. (1963). "The Student's Flora of Tasmania", pt. 2. (Gov. Printer: Hobart).
Drury, D.G. (1970). A fresh approach to the classification of the genus *Gnaphalium* with particular reference to the species present in New Zealand. *N.Z. J. Bot.* 8:222-248.
Eichler, H. (1965). "Supplement to J.M. Black's Flora of South Australia". (Gov. Printer: Adelaide).
Everist, S.L. (1959). Strangers within the gates. *Qld Natural.* 16:49-60.
Ewart, A.J. and Tovey, J.R. (1909). "The Weeds, Poison Plants, and Naturalized Aliens of Victoria". (Gov. Printer: Melbourne).
Fitter, A. (1978). "An Atlas of the Wild Flowers of Britain and Northern Europe". (Collins: London).
Francis, G.W. (1855). Letter to W.J. Hooker reproduced in Best (1965), *vide supra.*
Francis, G.W. (1859). "Catalogue of the Plants under Cultivation in the Government Botanic Gardens, Adelaide, South Australia". (Gov. Printer: Adelaide).
Francis, G.W. (1859a). Pasture grasses. *Farm and Garden* 1:27.
Gemmell, N. (1975). Some notes on Ferdinand von Mueller and the early settlement of Bugle Ranges. *S.A. Naturalist* 49:51-64.
Hackett, E. & W. (1876). Flower Seeds (Catalogue). *Garden and Field.* 1:209-218.
Heyne, E.B. (1871). "The Fruit, Flower and Vegetable Garden". (Andrews: Adelaide).
Heyne, E.B. (1882). List of Garden, Agricultural and Other Seeds. Supplement to *Garden and Field*, May 1882.
Howes, F.N. (1974). "A Dictionary of Useful and Everyday Plants and their Common Names". (University Press: Cambridge).
Kloot, P.M. (1980). Dr. Richard Schomburgk's 'Naturalised Weeds' (1879). *J. Adelaide Bot. Gard.* 2:195-220.
Kraehenbuehl, D. (1981). Dr. H.H. Behr's two visits to South Australia in 1844-45 and 1848-49. *J. Adelaide Bot. Gard.* 3:101-124.
Lanjouw, J. and Stafleu, F.A. (1957). Index Herbariorum Part II (2) Collectors *Regnum Vegetabile* 9.
Linneaus, C. (1753). "Species Plantarum" 2 vols. Stockholm. (Ray Society facsimile, London, 1957-59).
Loudon, J.C. (1830). "Loudon's Hortus Brittanicus". (Longman: London).
Loudon, J.C. (1835). "An Encyclopaedia of Agriculture". (Longman: London).
McEwin, G. (1843). Catalogue of plants grown at Melbourne Cottage, North Adelaide in J. Allen (ed.) "The South Australian Almanack and General Directory for 1844". (Allan: Adelaide).
McEwin, G. (1847). Horticultural and botanical sketch of the colony in J. Stephens (ed.) "The Royal South Australian Almanack and General Directory for 1848". (Stephens: Adelaide).
Mahoney, E.S. (1928). The first settlers at Gawler. *Proc. Royal Geogr. Soc., S. Austral. Br.* 28:53-82.
Meinig, D.W. (1962). "On the Margins of the Good Earth". (Rand McNally: Chicago).
Molineux, A. (1879). Received. *Garden and Field* 5:92.

Moore, D.M. (1972). *Datura* in T.G. Tutin *et al.*, "Flora Europaea", vol. 3. (University Press: Cambridge).
Mueller, F. (1850). Notes on South Australian botany. *S. Austral. Register* February 19, 1850.
Mueller, F. (1853). Flora of South Australia, displayed in its fundamental features and comparatively. *Hooker's J. Bot. Kew Gard. Misc.* 5:65-72.
Mueller, F. (1868). *Frag. Phyt. Aust.* 6:114.
Mueller, F. (1873). *Frag. Phyt. Aust.* 8:126.
Munir, A.A. (1981). Verbenaceae in J.P. Jessop (ed.) "Flora of Central Australia". (Reed: Sydney).
Noble, J.C. and Whalley, R.D.B. (1978). The biology and autecology of *Nitraria* L. in Australia. *Aust. J. Ecol.* 3:141-177.
Pascoe, J.J. (1901). "History of Adelaide and Vicinity". (Hussey and Gillingham: Adelaide).
Perring, F.H. and Walters, S.M. (1976). "Atlas of the British Flora". 2nd Ed. (EP Publishing: East Ardsley).
Piggin, C.M. (1977). The herbaceous species of *Echium* (Boraginaceae) naturalized in Australia. *Muelleria* 3:215-244.
Ridley, H.N. (1930). "The Dispersal of Plants throughout the World". (Reeve: Ashford).
Robertson, E.L. (1957). "Flora of South Australia", vol. 4, 2nd Ed. (Gov. Printer: Adelaide).
Ross, J.H. (1976). An analysis of the flora of Victoria. *Muelleria* 3:169-176.
Ryves, T.B. (1977). Notes on wool-alien species of *Lepidium* in the British Isles. *Watsonia* 11:367-372.
Schlechtendal, D.F.L. (1847). Bestimmung und Beschreibung der vom Dr. Behr in Sudaustralien gesammelten Pflanzen. *Linnaea* 20:559-672.
Schomburgk, R. (1870). "Report of the Director of Botanic Garden, 1869". (Gov. Printer: Adelaide).
Schomburgk, R. (1875). "The Flora of South Australia". (Gov. Printer: Adelaide).
Schomburgk, R. (1879). "On the Naturalised Weeds and Other Plants in South Australia". (Gov. Printer: Adelaide).
Schomburgk, R. (1885). "Annual Report of the Director of the Botanic Gardens for 1884". (Gov. Printer: Adelaide).
Sinclair, G. (1816). "Hortus Gramineus Woburnensis". (London).
Stevenson, G. (1839). Gardening in South Australia in "Royal South Australian Almanack and General Directory for 1840". pp. 21-56 (Thomas: Adelaide).
Stevenson, G. (1839a). Gardener and Farmer's Calendar in "Royal Australian Almanack and General Directory for 1840". pp. 9-20. (Thomas: Adelaide).
Stevenson, G. (1843). Horticultural and Agricultural Calendar, The Field in J. Allen (ed.). "The South Australian Almanack and General Directory for 1844". (Allen: Adelaide).
Symon, D.E. (1964). Contributions to the flora of South Australia. *Trans. Roy. Soc. S. Austral.* 88:5-13.
Symon, D.E. (1981). The solanaceous genera *Browallia*, *Capsicum*, *Cestrum*, *Cyphomandra*, *Hyoscyamus*, *Lycopersicon*, *Nierembergia*, *Physalis*, *Petunia*, *Salpichroa* and *Withania* naturalised in Australia. *J. Adelaide Bot. Gard.* 3:133-166.
Symon, D.E. (1981a). A revision of the genus *Solanum* in Australia. *J. Adelaide Bot. Gard.* 4:1-367.
Turner, F. (1912). *Sydney Morning Herald.* December 7, 1912. p. 2.
Wace, N.M. (1978). Human modification of the natural ranges of plants and animals in D. Walker and J.C. Guppy (eds.) "Biology and Quaternary Environments". (Aust. Academy of Science: Canberra).
Wace, N.M. (in press). Discovery, exploitation, settlement and scientific investigation of the St. Francis Islands, Nuyts Archipelago. *Trans. Roy. Soc. S. Austral.*
Webb, D.A. (1968). *Lythrum* in T.G. Tutin *et al.*, "Flora Europaea", vol. 2. (University Press: Cambridge).
Willis, J.H. (1972). "A Handbook to Plants in Victoria", vol. 2. (University Press: Melbourne).
Yelland, E.M. (ed.) (1970). "Colonists, Copper and Corn in the Colony of South Australia 1850-51". (Hawthorn Press: Melbourne).
Zohary, M. (1962). "Plant Life of Palestine—Israel and Jordan". (Ronald Press: New York).

Index to Scientific Names

Synonyms, misapplied, misspelt or illegitimate names are in italics.

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THE AUSTRALIAN GENUS *GUNNIOPSIS* PAX (AIZOACEAE)

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Abstract

Gunniopsis, which includes all Australian species previously included in *Aizoon* L. and *Neogunnia* Pax & Hoffm., is revised. Fourteen species are recognised and *G. calcarea*, *G. calva*, *G. divisa*, *G. papillata*, *G. propinqua*, *G. rubra* and *G. tenuifolia* are described as new. Two new combinations, *G. kochii* and *G. septifraga* are made. All species are illustrated and distribution maps and ecological data are provided.

Gunniopsis is compared with *Aizoon* L. and *Aizoanthemum* Dinter ex Friedr., two African genera with which *Gunniopsis* has previously been compared or considered synonymous. Pollen, capsule and seed characters are discussed and illustrated.

The majority of *Gunniopsis* species appear to be protandrous outcrossers, while a few are autogamous.

Introduction

The Australian species which have been previously referred to the genera *Aizoon* L., *Gunniopsis* Pax, *Gunnia* F. Muell. and *Neogunnia* Pax & Hoffmann are small succulent shrubs or herbs which are widespread throughout the eremaean zones of Western and South Australia with a few species extending into the adjacent portions of the Northern Territory, Queensland and New South Wales.

With the exception of the shrubby *Gunniopsis quadrifida* which is very widespread and an important component of succulent shrublands in many areas, especially on saline soils in salt lake systems, most of the species have been poorly understood taxonomically. Doubt over the exact number of species found in Western Australia, for example, has resulted in considerable confusion. Gardner in his 1930 census listed six species under *Gunniopsis* and *Gunnia*, Blackall & Grieve (1954) included four under *Gunniopsis* and *Gunnia* while Green (1981) listed five under *Aizoon*, *Gunniopsis* and *Neogunnia*. *Aizoon kochii* Wagner, recognised by Toelken (1981) as a good species, was previously considered by Black (1924, 1948) to be merely a variant of *A. zygophylloides* F. Muell. and presumably Jacobs and Pickard (1981) accepted Black's view. Black's concept of *A. zygophylloides*, however, was largely based on an herbaceous species, *G. papillata*, which is vegetatively very similar to *G. kochii*. *Gunniopsis* (*Aizoon*) *zygophylloides* is a shrub restricted to rocky situations in central South Australia and the southern part of the Northern Territory. In addition to Black's misapplication of this name, West Australian authors had misapplied it to a previously undescribed perennial species restricted to the Nullarbor region (*G. calcarea*).

The apparent polymorphy of *A. zygophylloides* and the mixture of taxa from Western Australia indicated that a revision of the Australian species was long overdue. Furthermore, it was also considered essential that a re-evaluation of the generic limits of *Aizoon*, *Gunniopsis* and *Neogunnia* be carried out because of the uncertainty by various authors as to the status of the Australian species and whether *Aizoon* and *Gunniopsis* were congeneric or not.

History of the Australian Species

Aizoon was described by Linnaeus in 1753 to accommodate three species originating from the African region. Since this date the number of described species in this genus (sens. str.) has increased to about 20 (Dyer, 1975).

In 1859, Mueller described a number of new species from plant collections made by Hergolt on the Babbage Expedition to northern South Australia. Among the new species described were two collected at Stuart's Creek and named *Sesuvium quadrifidum* and *Gunnia septifraga*. Two years later, Mueller (1861) transferred the former species to *Aizoon* without comment, although previously he had noted (Mueller, 1859) that the ovary shape of *Sesuvium quadrifidum* was close to *Aizoon*. In 1871, Mueller described a second Australian species, *A. zygophylloides*, in the genus and three further species from Australia have been added by Wagner (1904) and Ewart (1908).

Pax (1894), in his treatment of the Aizoaceae in Pflanzenfamilien considered *Aizoon quadrifidum* to be distinct from the African species and placed it in a new genus *Gunniopsis*. He made, however, no mention of *A. zygophylloides* the only other Australian species known at that time. Diels (1904) followed Pax in recognising *Gunniopsis* and described a new species, *G. intermedia*, and transferred *A. zygophylloides* to this genus. This new combination was overlooked by all subsequent authors who have always attributed it to Maiden & Betche (1916). Black (1924), Gardner (1930) and Blackall & Grieve (1954) also followed Pax in recognising *Gunniopsis*.

Pax & Hoffman (1934) reverted to the use of *Aizoon* in the broad sense including *Gunniopsis* in the synonymy. They placed *Gunnia septifraga* and Bentham's (1867) *G. drummondii* in a new genus *Neogunnia* since Mueller's generic name *Gunnia* was illegitimate because the name had previously been used by Lindley in 1834. Black (1948) followed Pax & Hoffmann (1934) and placed the South Australian species of *Gunniopsis* in *Aizoon* and more recent authors have also recognised only *Aizoon*, e.g. Beard (1965), Toelken (1981), Jacobs & Pickard (1981). Green (1981) in his census of Western Australian plants used *Aizoon* for those species already described as, or transferred to that genus, but he also listed one species of *Gunniopsis* which had never been transferred.

Generic delimitation of *Aizoon*, *Aizoanthemum* and *Gunniopsis*

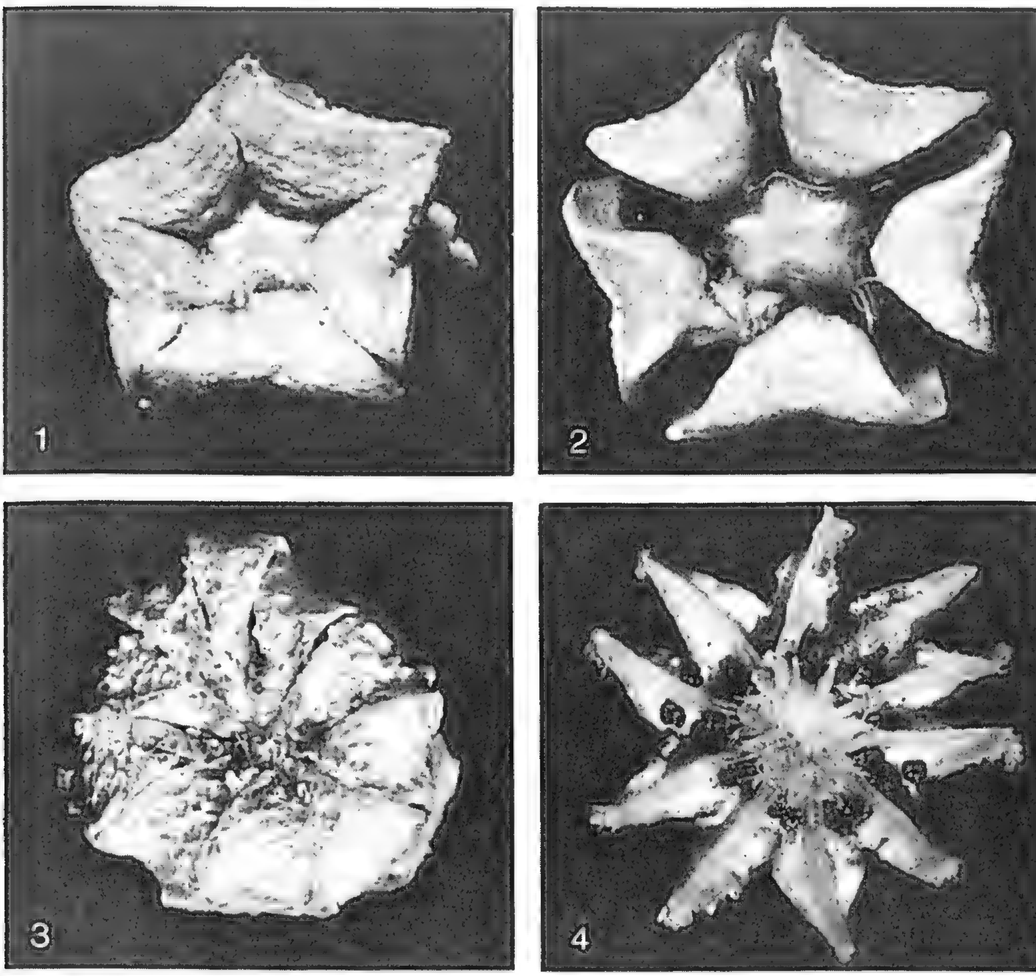
The superficial resemblance of *Aizoon*, *Aizoanthemum* and *Gunniopsis* have, to a large extent, contributed to the confusion between the genera. Adamson (1959), in his treatment of the South African species of *Aizoon*, subdivided the genus into three subgenera based on these three genera. He provided a key to the subgenera and basically distinguished them, as follows:-

1. Subgenus *Aizoon*—flowers 5-merous, carpels 5, valves not spreading, not hygroscopic.
2. Subgenus *Aizoanthemum*—flowers 5-merous, carpels 5, 7 or 10, fruit valves spreading, hygroscopic.
3. Subgenus *Gunniopsis*—flowers 4-merous, carpels 4, fruit with twice as many valves as carpels, hygroscopic.

His treatment of the subgenera appears to be superficial as he misinterpreted various features of the capsules of his subgenera *Aizoon* and *Gunniopsis*. Contrary to his view, the valves of *Aizoon* are hygroscopic, although they do not recurve like those in subgenus *Aizoanthemum*, but merely become displaced outwards separating the valves (Figs 1 & 2).

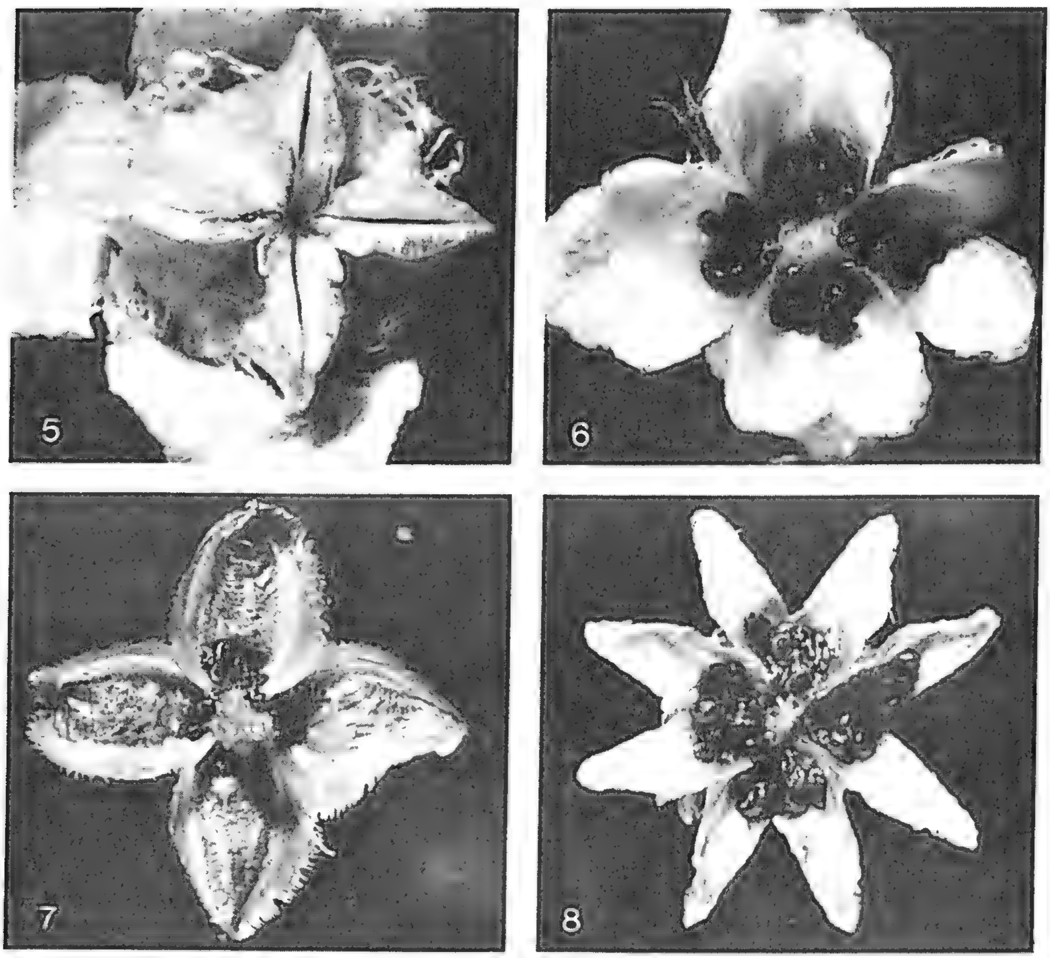
The capsule valve in most species of *Gunniopsis* splits, because of its shape, as the capsule opens for the first time with the result that each valve becomes shallowly or deeply lobed (see Fig. 44), and the capsule in the closed state may appear to have eight valves. Adamson does not indicate whether he studied any species from subgenus *Gunniopsis* but from his misinterpretation of the capsule valves it would seem unlikely. In his paper, Adamson cited Pax & Hoffmann as the authority for the subgenus *Gunniopsis* and although he gave a page reference for the combination, no such combination was published on that page or elsewhere in their treatment.

Adamson's subgeneric treatment of *Aizoon* has not been adopted by more recent authors working on South African plants. Both Friedrich (1970) and Dyer (1975) maintained *Aizoanthemum* as a distinct genus and after examining selected African material of *Aizoon* and *Aizoanthemum*, I would support this view.



Figs 1-4. 1, 2, *Aizoon glinoides*: closed and open capsule showing the outward displacement of the valves in the open position (*Johnson 72*, PRE). 3, 4 *Aizoanthemum dinteri*: closed and open capsule. Note the medial position of the expanding keel tissue on the opened valves. (*Giess 8155*, PRE).

Of the two African genera under discussion *Aizoanthemum* appears to be more closely allied to *Gunniopsis*. Both share the hygrochastic capsule type in which the valves when wetted, recurve through 180° or more, being opened by specialised bands of tissue called expanding keels. This capsule type is characteristic of *Mesembryanthemum* and allied genera which are often treated as a separate family (Mesembryanthemaceae). In *Aizoanthemum* the position of the expanding keels is median (Fig. 4) while in *Gunniopsis* it is marginal (Fig. 6-8). In addition to the capsule similarities, *Aizoanthemum* has prominently papillose leaves and branches as do a number of the ephemeral species of *Gunniopsis*, e.g. *G. kochii*, *G. papillata*. A summary of the more important characteristics of *Aizoon*, *Aizoanthemum* and *Gunniopsis* is given in Table 1.



Figs 5-8. 5, 6, *Gunniopsis intermedia*: closed and open capsule. Note the emarginate valve in the open capsule. (*Chinnock 5406*, AD); 7, *Gunniopsis divisa*: opened capsule showing the individual valves with prominent marginal expanding keels (*Tyson 3*, holotype MEL). 8, *Gunniopsis calva*: opened capsule showing valves almost split to their base. (*Specht & Carrodus 110*, AD).

Table 1. Distinguishing characters between *Aizoon*, *Aizoanthemum* and *Gunniopsis*.

Character	Aizoon	Aizoanthemum	Gunniopsis
Leaf arrangement	Alternate, very rarely opposite	Alternate, very rarely opposite	Opposite
Perianth segments	5	5	4
Stamen number	30 or more	30 or more	4-12, 30 or more
Stamen arrangement	2 or more whorls	2 or more whorls	2 or more whorls or in 4 groups alternate with the perianth segments
Capsule valve number	5	5 to 10	4 but sometimes appearing to be 8 due to bifid valves
Wetted valve movement	displaced outwardly	recurved through 180° or more	recurved through 180° or more
Position of expanding keel	median along valve	median along valve	marginal along valve
Seed sculpturing	ribbed	ribbed	variable but never ribbed

Previously, *Neogunnia (= Gunnia* F. Muell., non Lindl.), consisting of one species, *N. septifraga*, had always been treated as a distinct genus from the other Australian species which were then included in either *Aizoon* or *Gunniopsis*. *Neogunnia* was distinguished by its four stamens which were arranged alternately with the perianth segments, while the known species of *Gunniopsis* had 30 stamens or more. The latter are arranged either in four bundles each of which was positioned alternately with the perianth segments, similar to the stamens of *Neogunnia*, or in a series of whorls around the ovary. All other characters of *Neogunnia* agree with those of *Gunniopsis* and one of the new species, *G. propinqua*, described here, has 1 to 3 stamens at each junction between the perianth segments. This clearly links *G. septifraga* with those species having numerous stamens in each bundle (e.g. *G. rodwayi*). It has been found that in some populations of *G. septifraga* (e.g. *Chinnock 5262*) some plants had flowers with eight stamens arranged in pairs. The reduction in stamen number, in my opinion, appears to be directly related to breeding systems and is not considered taxonomically significant at the generic level (see discussion under Floral Biology).

Notes on Morphology

(a) *Plant Size*

As in the case with many ephemeral plants the size attained by the individual is largely dependent upon the amount and regularity of precipitation received during the growing period. In favourable seasons ephemeral *Gunniopsis* species like *G. kochii*, *G. papillata*, *G. intermedia* and *G. rodwayi* grow rapidly and plants may attain 50 cm in diameter, but in poor seasons the few plants which develop may only be a few centimetres across. Accordingly, only ranges of measurements are given except for where an extreme is well beyond the general range.

(b) *Indumentum*

The epidermal vestiture, where present, consists of either scales or uniseriate hairs. The uniseriate hairs present on *G. quadrifida* form a dense tomentum on the branches and leaves while in most species the trichomes are more scattered and usually succulent. On drying these hairs collapse to form flattened plates or become crisped along the margin. *G. calcarea* is the only species possessing scales.

(c) *Surface Features*

The epidermal cells on various parts of the plant, e.g. branches, leaves, perianth segments, ovary, are prominently raised in many species and give the surface its papillose appearance, but on drying it is sometimes difficult to discern this.

In many of the herbaceous species, which grow in very saline situations, salt crystallizes in the epidermal or subepidermal layers of the branches, leaves or on the outside surface of the perianth-segments. These crystals have only been noted in dried material and appear as isolated crystals which may or may not project through the surface or as irregular protuberances of crystal clusters, which have been termed pustules.

(d) *Leaves*

The leaves of all species are opposite, connate at the base and in some species form a short sheath along the node. The term leaf is used here to include true basal leaves and the leafy bracts subtending flowers, as in most cases they are indistinguishable. In *G. tenuifolia*, the leaves subtending the flowers are considerably smaller, but otherwise identical to vegetative leaves.

(e) *Plant colour*

Although a majority of species have been studied in the living state, a number, namely *G. divisa*, *G. calva*, *G. kochii*, *G. papillata* and *G. propinqua* have only been seen in the dried state or seen before this study was commenced and consequently the colour of vegetative structures had not been noted. It is considered likely that variation in colour, other than green, is found as it occurs in other herbaceous species.

(f) *Inflorescence*

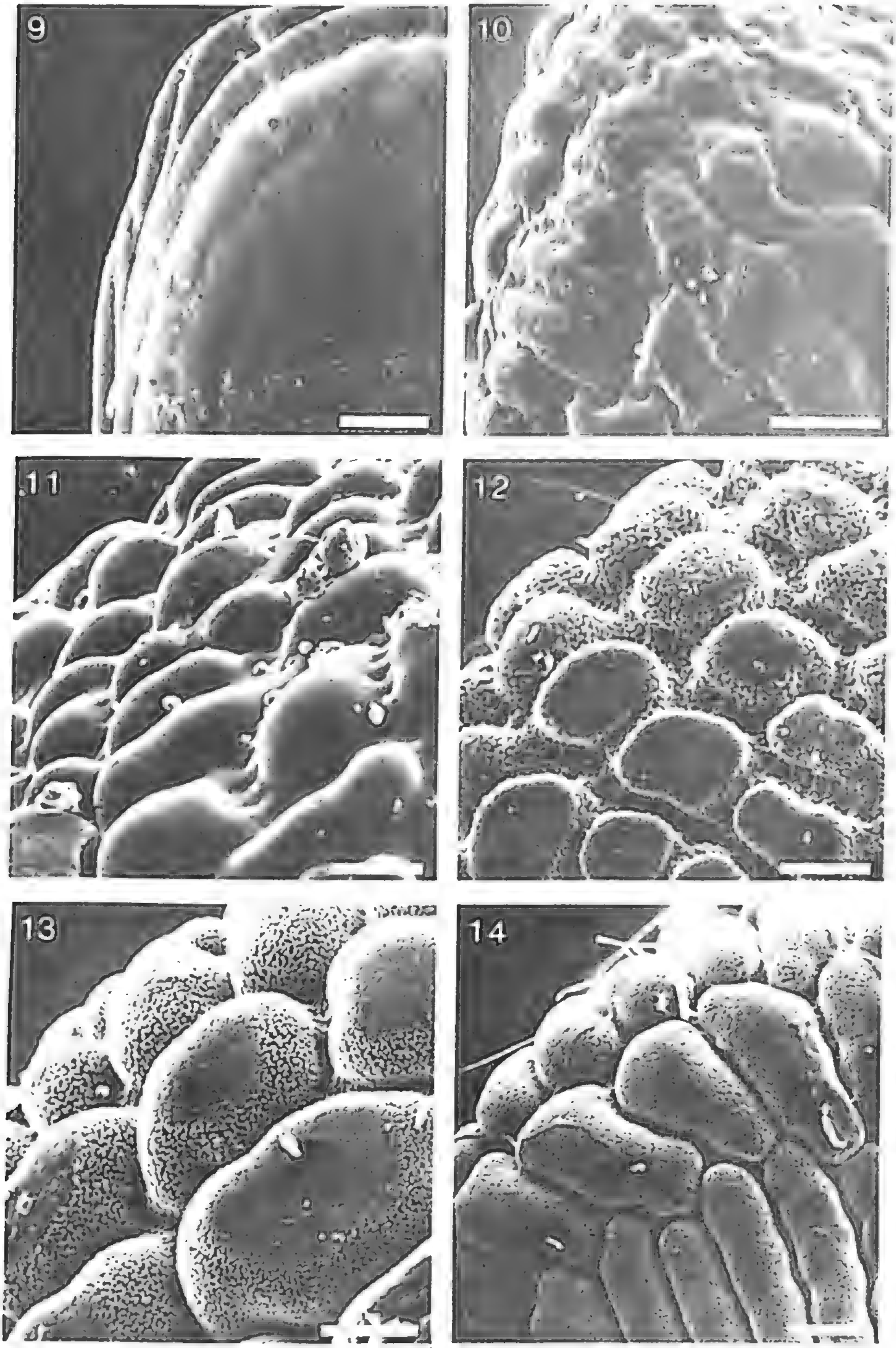
The inflorescence in *Gunniopsis* is usually a thyrsoid in well-developed plants but is often reduced in plants with less vigorous growth to a dichasium or a single flower (cf. Troll & Weberling, 1981).

The two large shrubby species, *G. quadrifida* and *G. tenuifolia* have distinct vegetative and floral phases of growth. This is most marked in the latter species, which has the inflorescence raised above the leaves. After the flowering period, new vegetative shoots arise below the inflorescences in both species and gradually overtop them. The whole plant, except for initial vegetative growth of seedlings of the shrubby species, *G. zygophylloides* and *G. calcarea*, and all the herbaceous ones, except for *G. divisa* and *G. glabra*, can be interpreted as inflorescence. Once the primary shoot is terminated by a flower, lateral branches develop in the axils of the subtending leafy bracts, which in turn are also terminated by flowers. This results in a pseudo-dichotomous branching pattern (e.g. Fig. 41, A & C).

The inflorescence of *G. glabra* is reduced to a single flower. In this case axillary buds remain dormant so that the flowering branch bears 5 or 6 pairs of leafy bracts before a flower terminates it. The inflorescence of *G. divisa* appears to be somewhat intermediate between the two conditions.

(g) *Perianth*

In all but two species, *G. rubra* and *G. divisa*, the perianth segments are fused together in the lower third or lower. The colour of the inside surface of the perianth segment, with two exceptions, is constant for a species. In *G. papillata* it varies from white to yellow and *G. propinqua* from white to pink.



Figs 9-14. Variation in sculpturing of the seed testa: 9, *G. rubra*; 10, *G. septifraga*; 11, *G. tenuifolia*; 12, *G. kochii*; 13, *G. calcarea*; 14, *G. divisa*. (Scale = 50 µm.)

(h) *Seeds*

The shape of the seed and the cells of the testa were found to be very useful in distinguishing species of *Gunniopsis*, and within a species the ornamentation of the testa was relatively uniform. Variation in basic seed shape as seen in distal view is illustrated by *G. calva* (Fig. 44), *G. divisa* (Fig. 45) and *G. glabra* (Fig. 46). In side view the seed of all species is ovoid.

The descriptive terms used for the sculpturing of the testa follow Stearn (1973), although "colliculate" has been broadened to include the more elongate cell types as found, for example, in *G. divisa.*

The types of sculpturing of the testa of *Gunniopsis* varies considerably ranging from an almost smooth surface except for the sulcated outer edge (Fig. 9) to rugose (Fig. 10), colliculate (Figs 11-14), tuberculate (Figs 15-18) and granulate (Fig. 37G). The cells are often arranged in distinct rows, e.g. Figs 40K, 43H, 45H.

In contrast to *Gunniopsis* the seeds of *Aizoanthemum* (*A. dinteri*, *A. galenioides*, *A membrum-connectens*) and *Aizoon* (*A. canariense*, *A. glinoides*, *A. sarmentosum*, *A. rigidum*), which I have examined are similar in size and shape to *Gunniopsis*, but differ in that the testa is ribbed (Fig. 20). In *G. rodwayi* tubercles along the outer edge of the testa sometimes partially coalesce and approach the ribbed condition found in the African genera, but the individual cells always remain distinct, e.g. Fig. 19.

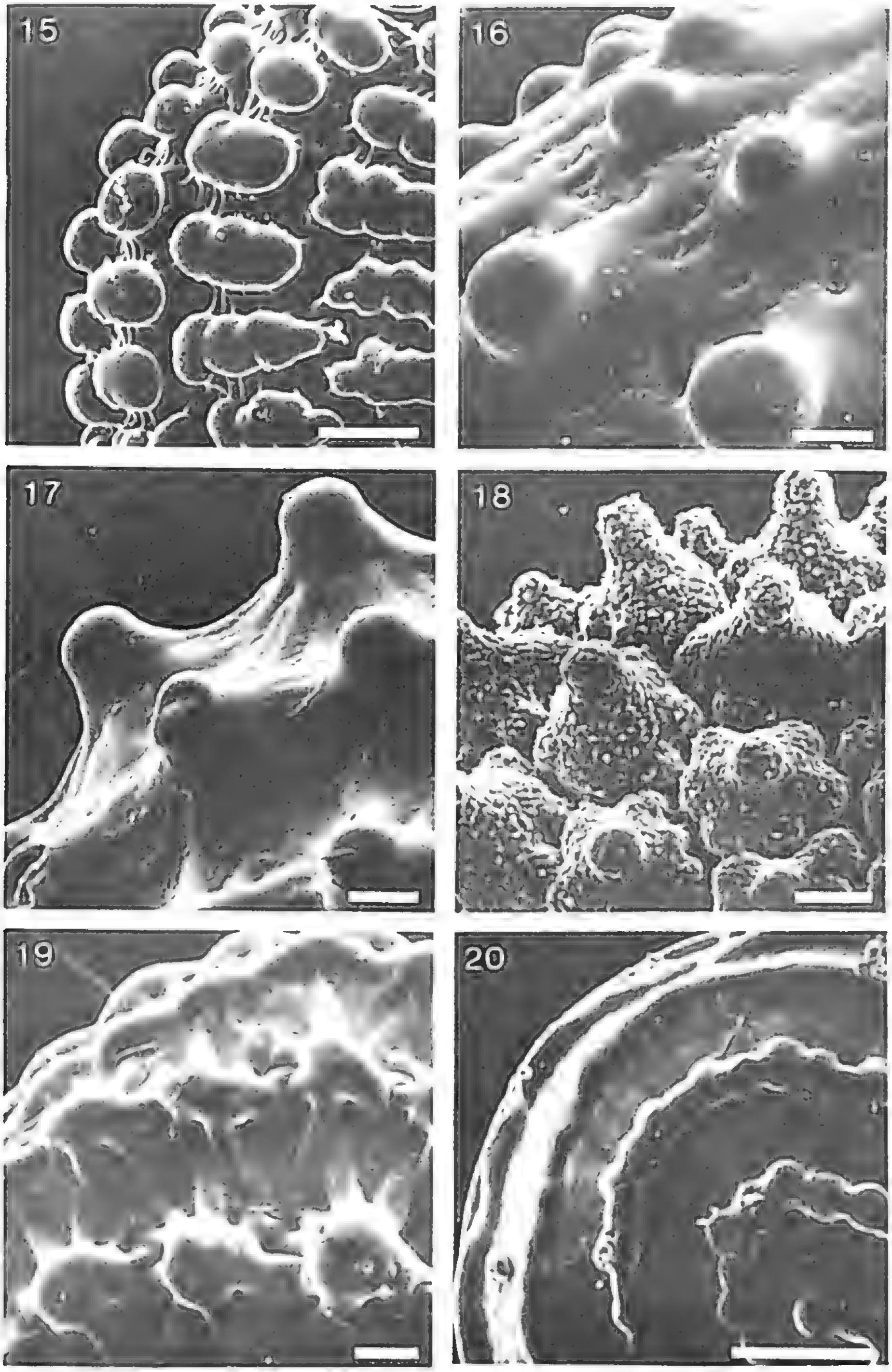
(i) *Palynology*

Erdtman (1952), who studied ten genera of the Aizoaceae, found the pollen grains to be fairly uniform throughout the family. Pollen grains of all species of *Gunniopsis* and selected species of *Aizoon* and *Aizoanthemum* were examined on an ETEC autoscan SEM and an Olympus light microscope. In all three genera the pollen grains were found to be uniformly tricolpate, prolate-subprolate, and the sexine punctitegillate and prominently papillose (Figs 21-26). In *Gunniopsis* the pollen size range was 22.5-40 (-45) x 15-25 (-30) μm.

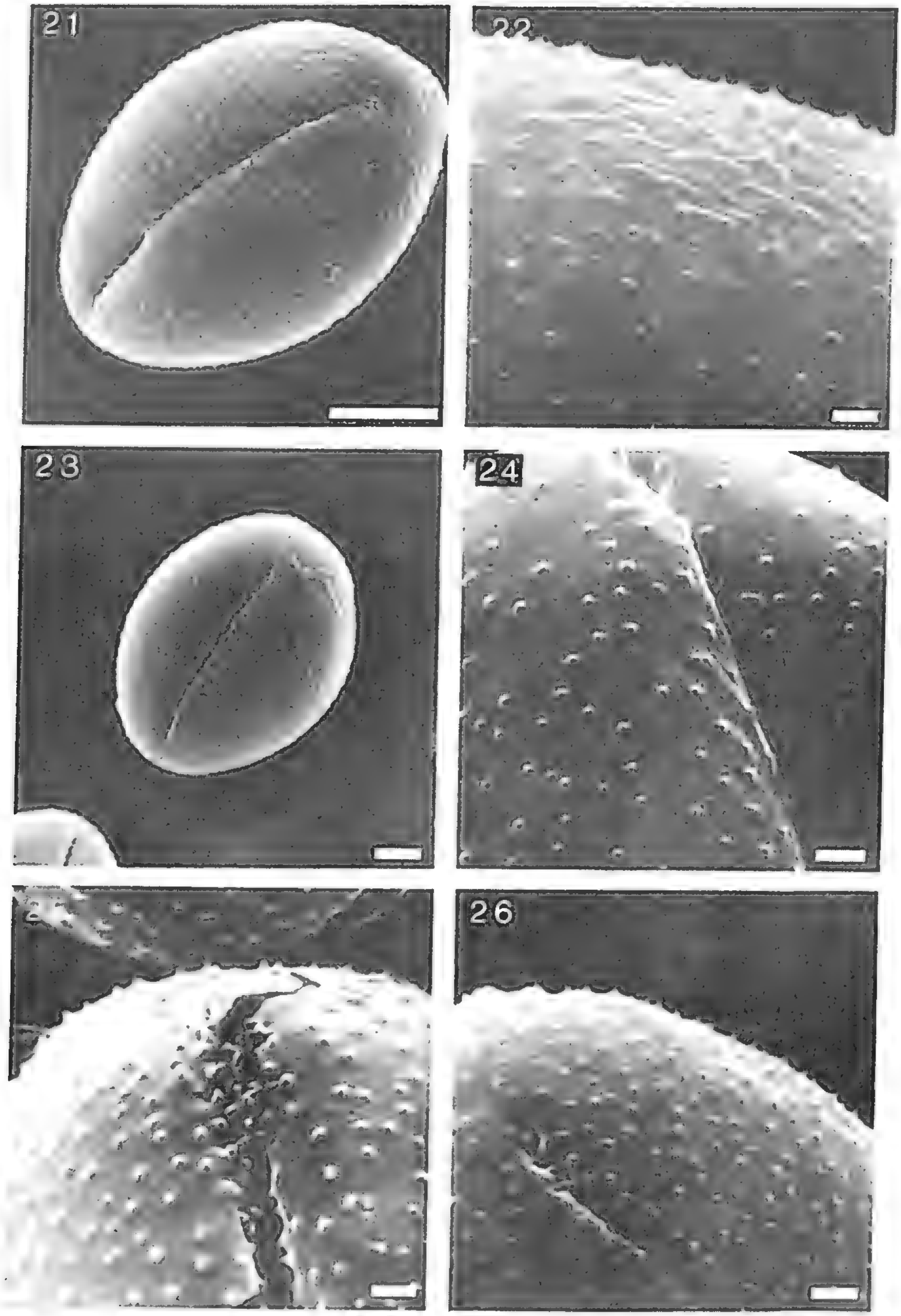
Floral Biology

While I was conducting taxonomic field studies on *Gunniopsis* populations in Western Australia in 1980-81, the opportunity was taken to examine flowers of the various species to try and determine the breeding systems and to note and observe any insects visiting them. In addition observations have been made on the flowers of three species in cultivation, and some information was also obtained from dried herbarium material. Unfortunately, neither the time nor opportunity allowed an examination of such aspects of the breeding systems as pollen viability and longevity, stigma receptivity or self incompatability so that the information reported here can only be taken as a guide to the probable syndromes found within the genus.

The majority of species of *Gunniopsis* are protandrous while two, possibly three species appear to be autogamous. Pollination of protandrous species appears to be carried out by a variety of insects from the orders Lepidoptera, Hymenoptera, Diptera and to a lesser extent Coleoptera. Members of all these groups have been observed feeding on *G. quadrifida* and *G. rodwayi*, although the most common visitors were bees including various native species and the introduced honey bee (Fig. 28). At one locality even ants were swarming over plants of *G. quadrifida* and it would seem likely that pollination would occur under such circumstances, especially if the species is self-compatible.



Figs 15-20. Variation in sculpturing of the seed testa. 15, *G. papillata*; 16, *G. quadrifida*; 17, *G. glabra*; 18, *G. intermedia*; 19, *G. rodwayi*; 20, *Aizoanthemum dinteri*. (Scale = 50 μm.)



Figs 21-26. Pollen morphology of *Gunniopsis*, *Aizoon* & *Aizoanthemum*; 21-22, *G. quadrifida* (*Chinnock 5187*, AD); 23-24, *G. septifraga* (*Chinnock 5262*, AD); 25, *Aizoon glinoides* (*Maguire 759*, PRE); 26, *Aizoanthemum galenoides* (*Giess 2569*, PRE). (Scale: Figs 21 & 23 = 10 μm; figs 22, 24-26 = 1 μm.)

Figs 27-28. Insects feeding on *Gunniopsis quadrifida*: 27, unidentified beetle; 28, *Apis mellifera*.

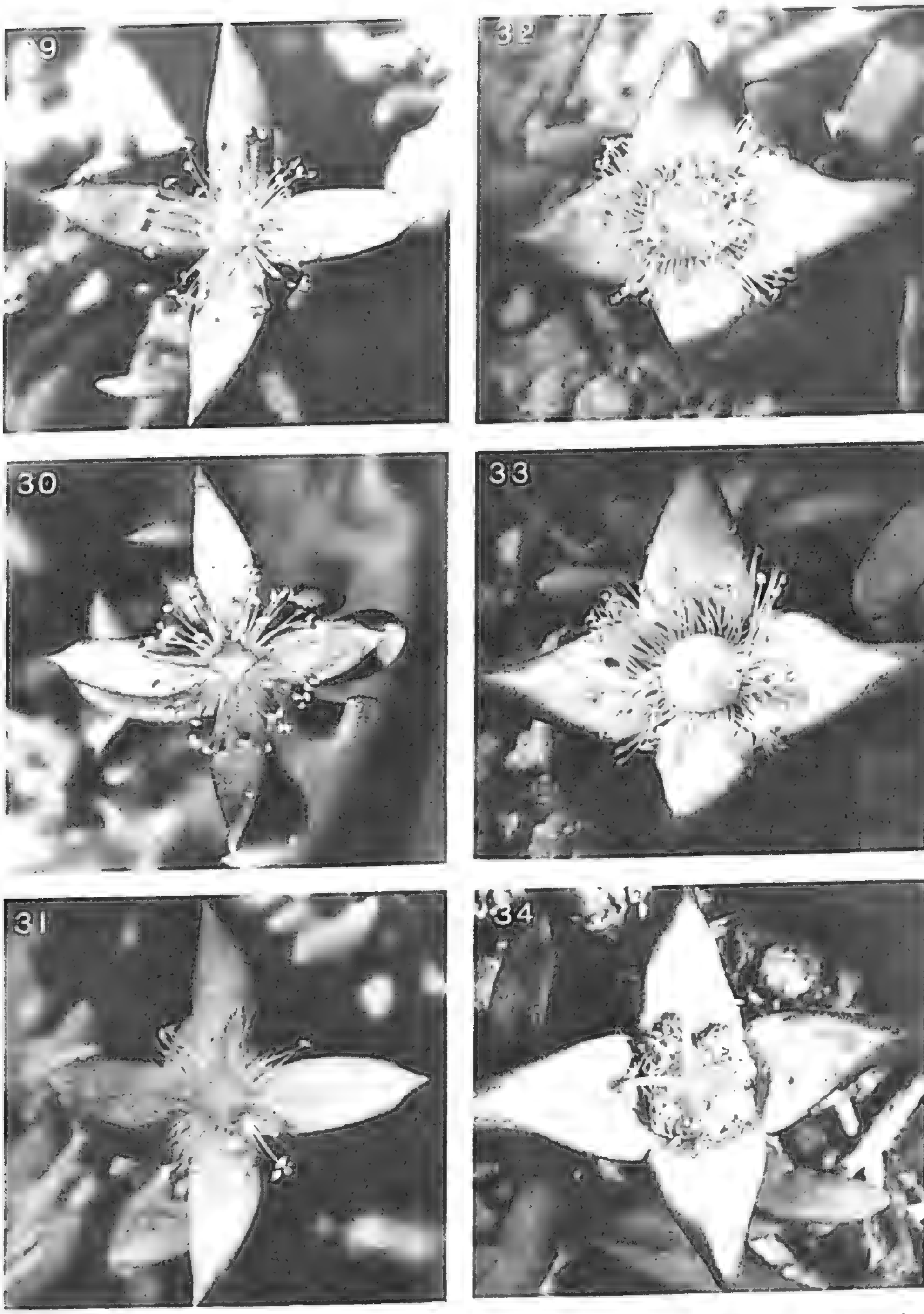
Observations were made on the flowers of plants of *G. calcarea* and *G. glabra* cultivated in Adelaide. The duration from when the flower first opens until stigma separation was found to differ considerably. It must be noted here that flowers of all the species observed open in the morning and close again each evening.

G. calcarea (Figs 29-31) has the stamens arranged in two whorls. When the flower opens (day 1) the anthers are all intact and either erect or curved over the centre of the flower. At this stage the stigmas have not fully developed and the four are erect and appressed together along the receptive surfaces. Late on day 1 and early on day 2 the anthers of the inner whorl are spreading and beginning to dehisce. The stigmas are also fully elongated and mature but still appressed together. On day 3 all the anthers have dehisced and reflexed back onto, and between, the perianth segments. The stigmas separate and rest on the ovary with the receptive surface fully exposed. The flower illustrated continued to open for another 5 days but did not open on day 9.

The above process took considerably longer in *G. glabra* (Figs 32-34). In this species which has up to 9 whorls of anthers, all anthers had dehisced only on day 8, and on day 9 the stigmas separated. The flower was still opening on day 22.

It was noted in both cultivated as well as plants in the field, that in the case of protandrous species the pollen was found to be shed shortly after the anthers had dehisced. As flowers of *Gunniopsis* close each evening, one cannot exclude the possibility that self pollination occurs, assuming that the species are self compatible. The fact, however, that most of the pollen from the anthers is lost before the stigmas separate seem to suggest that outcrossing is more likely to result.

In the non-protandrous species the styles spread and the anthers dehisce and deposit pollen on the apparently receptive surface before the flower opens. Consequently these species are thought to be autogamous. At least in *G. septifraga* I suspect cleistogamy to occur frequently. Rarely are there more than one or two flowers open on a plant at any one time, unlike protandrous species in which numerous flowers are open each day.



Figs 29-34. Development of protandrous flowers in two species of *Gunniopsis*. *G. calcarea* 29-31: 29, early day 2 outer anthers dehiscing; 30, late day 2 inner whorl of anthers start dehiscing, stigmas mature but erect and appressed; 31, late day 3 all anthers dehisced and reflexed, stigmas spreading. *G. glabra* 32-34, day 4 outer whorls of anthers progressively dehiscing inner whorls still incurved over stigmas; 33, day 8 all anthers dehisced and stigmas just separating; 34, day 13 stigmas spreading and very prominent, stamen remains shrivelled.

There would appear to be a correlation between floral characters, especially stamen number, and breeding systems. Protandrous species have large showy flowers which are pure white, yellowish-green, yellow or pink on the inside of the perianth segments. Stamens are numerous and either arranged in a series of whorls around the ovary (Fig. 35, A) or grouped in four bundles (Fig. 35, B). In contrast, autogamous species have small inconspicuous flowers often difficult to detect amongst the leaves and the stamens are reduced to 4 (Fig. 35, D).

The flower of *G. propinqua* (Fig. 35, C) appears to be intermediate between these two groups. These flowers, although small, are white or pink, raised above the leaves, and the number of stamens range from 4 to 12.

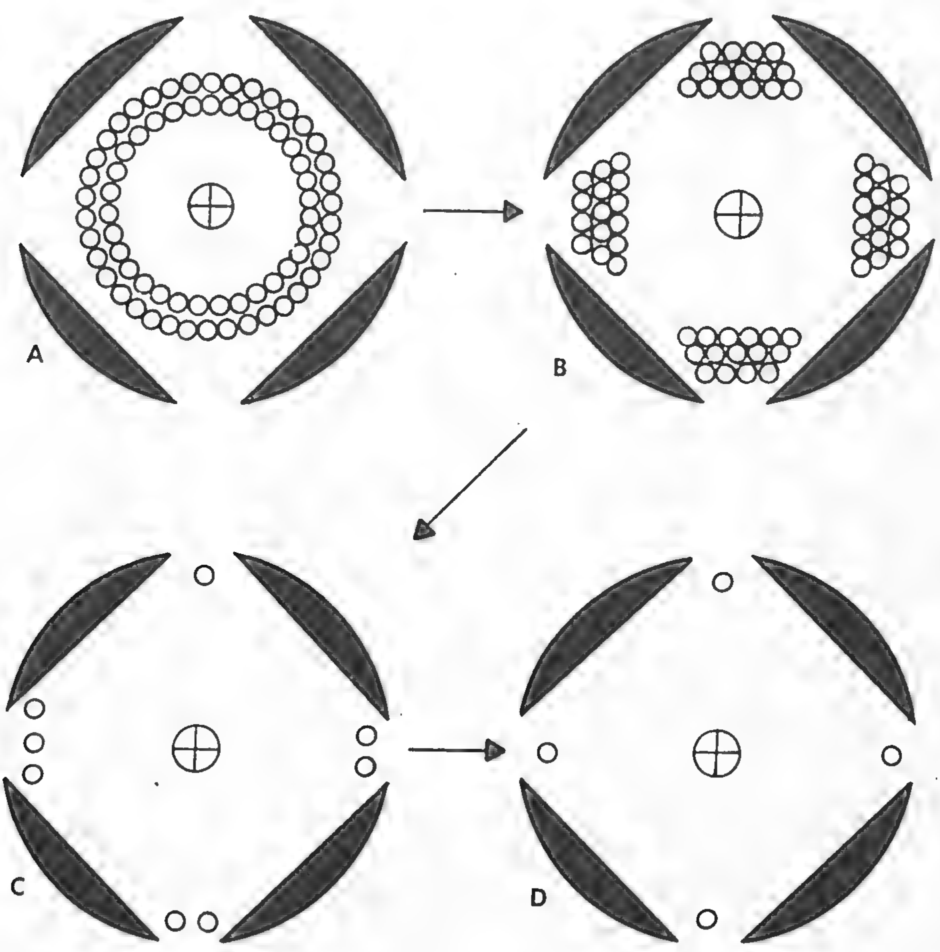


Fig. 35. Theoretical rearrangement and reduction of stamens in *Gunniopsis* accompanied by a change from protandry (A-B) to autogamy (D, ?C). A, stamens in whorls (2-9) around the gynoecium, e.g. *G. zygophylloides*, *G. glabra*. B, stamens numerous, aggregated into 4 groups, *G. quadrifida*, *G. tenuifolia* and *G. rodwayi*. C-D, stamens in one whorl and aggregated into four bundles with 1-3 stamens in each bundle, e.g. *G. propinqua* (C) and *G. septifraga* (D).

Distribution and Relationships of the Species

Gunniopsis is widespread throughout the salt lake—clay pan systems of the Eremaean zone (Burbidge, 1960) south of latitude 20° S, the South-West Interzone and the Avon Botanical District (South-West Province) Western Australia (Beard, 1980).

Apart from two widespread species, *G. quadrifida* and *G. septifraga*, which extend throughout most of the range of the genus, the remaining species occur in three distinct zones (Map 1): Zone A, which contains six endemic species extends from the Eastern Goldfields and Lake Carnegie in Western Australia westwards to the coast; Zone B, contains one endemic species and extends along the Nullarbor Plain from Western Australia to South Australia; Zone C, containing five endemic species extends from northern Eyre Pensinsula in South Australia north to the southern Northern Territory. One species, *G. papillata* also occurs in two small disjunct regions, one centred on Mt Isa and the other in the extreme north-west of New South Wales and south-west Queensland.

Species of Zone A

Five of the species restricted to this zone, namely *G. divisa*, *G. glabra*, *G. rodwayi*, *G. propinqua*, and *G. rubra* are more closely related to one another, or to *G. septifraga*, than to the species found in Zones B and C or *G. quadrifida*.

G. divisa, *G. glabra* and *G. rodwayi* are all closely allied sharing glabrous vegetative parts and similar structured leaves, but differ in the complexity of the inflorescence, the degree of dissection of the perianth segments, arrangement of the stamens and features of the seed. The similar shape and ornamentation of the seed and the basal fusion of the perianth segments in *G. glabra* and *G. rodwayi* suggest that these two species are more closely related to each other than to *G. divisa* which has seed with a shape and ornamentation suggesting a possible link with *G. kochii*. In addition, the perianth segments of *G. divisa* are free. The stamens of *G. rodwayi* are grouped in four bundles and it is considered that this feature links the species to the *G. septifraga* group.

G. propinqua and *G. rubra* are allied to *G. septifraga* sharing with this species a small stature, the leaf shape, reduced stamen number 4-12 (compared with more than 30 stamens in all other species) very small seeds and the apparent autogamous breeding system. The terete to oblong leaves and the arrangement of the stamens into four bundles of this group are features shared with the two shrubby species, *G. quadrifida* and *G. tenuifolia*.

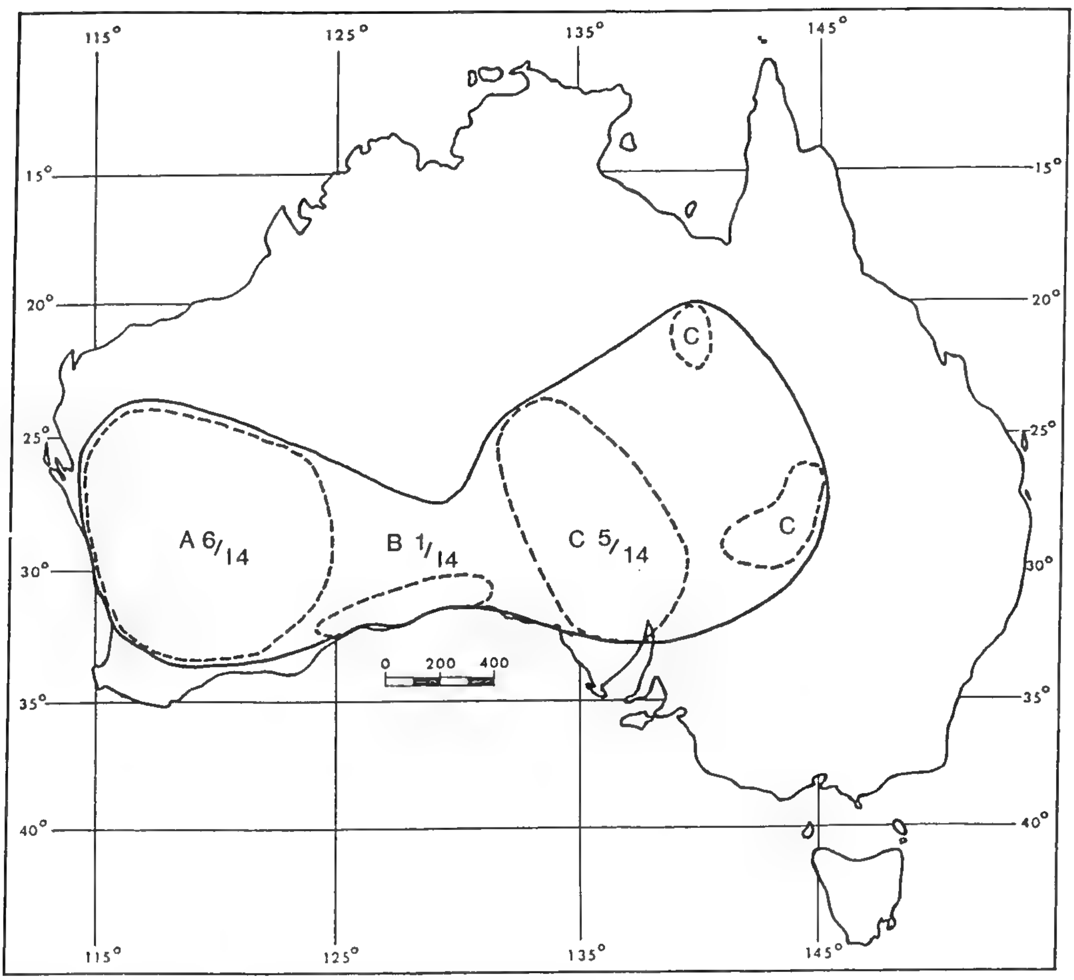
G. intermedia, the remaining species restricted to this zone, differs from the other endemics in having perianth segments coloured yellow inside, differently shaped leaves, and stamen filaments which have flattened bases. In these respects, *G. calva* would appear to be its closest relative.

Species of Zones B and C

The six species restricted to Zones B and C fall into three groups. Group 1 consists of *G. calcarea*, restricted to the Nullarbor Plain (Zone B), and *G. zygophylloides* extending throughout Zone C. Both are small shrubs with similar flowers, fruit and seed but differ in their type of indumentum and differently shaped leaves.

The second group consists of three annual species, *G. calva*, *G. papillata* and *G. kochii*. They share a similar habit and leaf shape but differ in the presence or absence of indumentum on the branches, the shape of the staminal filaments and the shape and ornamentation of the seed. The latter two species are very closely allied and difficult to distinguish unless seed is present or the colour of the inner surface of the perianth segment is known. Vegetatively the two are almost identical.

The third group, consisting of *G. tenuifolia*, is closely allied to *G. quadrifida*. These two shrubby species have similarly shaped leaves and stamens grouped in four bundles. They differ in the presence or absence of indumentum on the vegetative parts, the inflorescence, the colour of the inside surface of the perianth segments and the seed ornamentation.



Map 1. Distribution of *Gunniopsis* (solid line) showing the number of endemic species as a fraction of the number of species in the genus in Zones A-C (broken line).

GUNNIOPSIS Pax

Gunniopsis Pax in Engl. & Prantl., Nat. Pflanzenfam. 1st edn 3, 1b: 44 (1894); Diels, Bot. Jahrb. 35: 197 (1904); Black, Fl. S. Aust. ed. 1: 221 (1924); Gardner, Enum. Pl. Aust. Occid. 2: 42 (1930); Blackall & Grieve, West. Aust. Wildfls 1: 163 (1954).

Type species: *G. quadrifida* (F. Muell.) Pax

Aizoon sensu Benth., Fl. Aust. 3: 327 (1867); Bailey, Fl. Qd. 2: 706 (1900); Pax & Hoffm. in Engl. & Prantl, Nat. Pflanzenfam. 2nd edn 16C: 222 (1934) p.p.; Black, Fl. S. Aust. ed. 2: 341 (1948); Toelken in Jessop Fl. Cent. Aust. 35 (1981).

Gunnia F. Muell., Rep. Babb. Exp. 9 (1859); Benth., Fl. Aust. 3: 327 (1867); Gardner, Enum. Pl. Aust. Occid. 2: 42 (1930); Blackall & Grieve, West. Aust. Wildfls 1: 163 (1954), nom. illeg., non Lindl.

Neogunnia Pax & Hoffm. in Engl. & Prantl, Nat. Pflanzenfam. 2nd edn 16C: 225 (1934); Black, Fl. S. Aust. ed. 2: 340 (1948); Toelken in Jessop, Fl. Cent. Aust. 36 (1981); Jacobs & Pickard, Pl. N.S.W. 62 (1981); Cunningham et al., Pl. West. N.S.W. 295 (1981).

Annual or perennial, succulent herbs sometimes with a woody base to woody shrubs. *Leaves* at the base and on flowering branches opposite, exstipulate, sessile, connate. *Inflorescence* a thyrse composed of one or more dichasia, but because subtending bracts are leaf-like flowers often appear solitary and terminal. *Flowers* 4-merous. *Perianth* free or fused in the lower third or lower; segments valvate. *Stamens* in 1 to 9 whorls, 30 or more, or reduced to 4-12, evenly distributed around ovary or aggregated into four bundles alternate with perianth segments. *Pollen* 3-colpate, prolate to subprolate, sexine punctitegillate, papillose. *Carpels* 4, fused; stigmas filiform, sessile. *Fruit* a hygrochastic capsule; valves 4, acute or splitting to varying degrees when capsule first opens and becoming emarginate or bifid; valves when wetted recurved through 180° or more by marginal expanding keel tissue; expanding keels entire or prominently serrate; chambers 4, seed numerous, placentation axile. *Seed* ovoid to almost circular, crustaceous, embryo curved, often almost surrounding the endosperm.

The 14 species are endemic to Australia and widespread throughout the drier parts of the continent.

Key to Species

1. Stamens 4-12 2
1. Stamens 30 or more 4
2. Leaves oblong to oblanceolate; seeds white but brown along the outer edge, smooth or rugose; plant green or yellow .... 12. *G. septifraga*
2. Leaves linear; seeds brown, smooth; plant green to red 3
3. Valves of capsule deeply bifid; seeds triangular in distal view, the cells arranged in 5 to 7 rows; perianth white to pink; plant green .... 14. *G. propinqua*
3. Valves of capsule undivided; seeds lenticular, furrowed along the distal edge; perianth green; plant turning red with age .... 13. *G. rubra*
4. Leaves linear, terete; stamens arranged in four bundles 5
4. Leaves dorsiventrally flattened, ovate, obovate to lanceolate or oblanceolate; stamens in a continuous ring, rarely in four bundles 6
5. Branches and leaves glabrous except for the ciliate leaf bases; perianth yellow-green . 2. *G. tenuifolia*
5. Branches and leaves clothed in a white to yellow tomentum; perianth white .... 1. *G. quadrifida*
6. Branches glabrous 7
6. Branches possessing hairs or scales 13
7. Flowering branches wiry, flowers solitary; plant perennial with a prominent taproot ... 10. *G. glabra*
7. Flowering branches fleshy, flowers numerous or rarely 2-3; plant annual, lacking a taproot 8

8. Perianth segments bright yellow 9
8. Perianth segments white or pink 10
9. Branches and leaves smooth, shiny; WA .... 5. *G. intermedia*
9. Branches and leaves papillose, dull; SA, NT, Q, NSW .... 6. *G. papillata*
10. Perianth pink; leaves and branches papillose .... 7. *G. kochii*
10. Perianth white, leaves and branches smooth 11
11. Stamens arranged in four bundles .... 11. *G. rodwayi*
11. Stamens evenly distributed around the ovary 12
12. Flowering branches wiry; capsule valves undivided .... 9. *G. divisa*
12. Flowering branches fleshy; capsule valves deeply bifid .... 8. *G. calva*
13. Branches and leaves with flattened appressed ± circular scales .... 4. *G. calcarea*
13. Branches and leaves with long, flattened, or succulent hairs 14
14. Plant woody at least at the base; leaves ovate to oblanceolate .... 3. *G. zygophylloides*
14. Plant herbaceous; leaves oblong to oblanceolate 15
15. Perianth segments pink; seeds laterally expanded into broad lobes .... 7. *G. kochii*
15. Perianth segments white or yellow; seeds laterally flattened .... 6. *G. papillata*

1. **Gunniopsis quadrifida** (F. Muell.) Pax in Engl. & Prantl. Nat. Pflanzenfam. 1st edn 3, 1b: 44 (1894); Black, Fl. S. Aust. ed. 1: 221 (1924); Gardner, Enum. Pl. Aust. Occid. 2: 42 (1930); Blackall & Grieve, West. Aust. Wildfls 1: 163 (1954).

Type: (*D. Hergolt s.n.*), Stuart's Creek, not located; neotype here designated: *J.Z. Weber 5790*, 10 km S of Stuart Creek Homestead, South Australia, 6.x.1978 (AD; isoneotypes: BRI, CANB, K, MEL, PERTH, PRE).

Sesuvium quadrifidum F. Muell., Rep. Babb. Exped. 9 (1859).

Aizoon quadrifidum (F. Muell.) F. Muell., Frag. 2: 148 (1861); Benth., Fl. Aust. 3: 327 (1867); Bailey, Qd Fl. 2: 707 (1901); Black, Fl. S. Aust. ed. 2: 341 (1948); Toelken in Jessop, Fl. Cent. Aust. 36 (1981); Cunningham et al. Pl. West. N.S.W. 291 (1982).

Typification

The specimen collected by Hergolt at Stuart Creek was not located at either MEL or K, the only two herbaria where collections from the Babbage Expedition are known to be housed. Bentham (1867) appears to have seen the type as he provides more information than that found in the protologue, ("Desert at Stuart's Creek, *Hergolt*"); however, the other specimen cited by Bentham could not be located at MEL either.

In selecting a neotype a modern collection has been chosen in preference to one of the specimens subsequently seen by Mueller as these are of poor quality. The neotype selected was collected very close to the type locality and fits Mueller's description of *Sesuvium quadrifidum* well.

Shrub 0.3-1 x 0.3-1 (-1.3) m, compact, rounded ± divaricate with the branches, leaves and perianth segments (outside) covered with a yellow, grey or white scurfy tomentum. *Leaves* linear-terete, subterete in the lower part and flattened on the upper side, obtuse, (4-) 10-50 (-80) x 1.1-3 mm. *Flowers* pedicellate. *Perianth* fused basally, segments almost equal or two distinctly larger, ovate to triangular, apex acute or acuminate, 5.5-28 x 3.7-10.1 mm, outside surface white scurfy tomentose; inside surface white, prominently papillose. *Stamens* numerous, in 3 or more whorls, grouped into four bundles alternate with perianth segments; filaments terete, papillose; anthers smooth. *Ovary* ovoid, 4-ribbed, papillose. Capsule 4-ribbed, 4.5-8.5 x 5-9.5 mm; valves when opened deeply bifid so that the capsule closed appearing 8-valved. *Seed* 1.3-1.8 x 1.1-1.5 mm, ovoid, black, tuberculate. (Figs 16, 21, 22, 27, 28, *36*. Map 2).

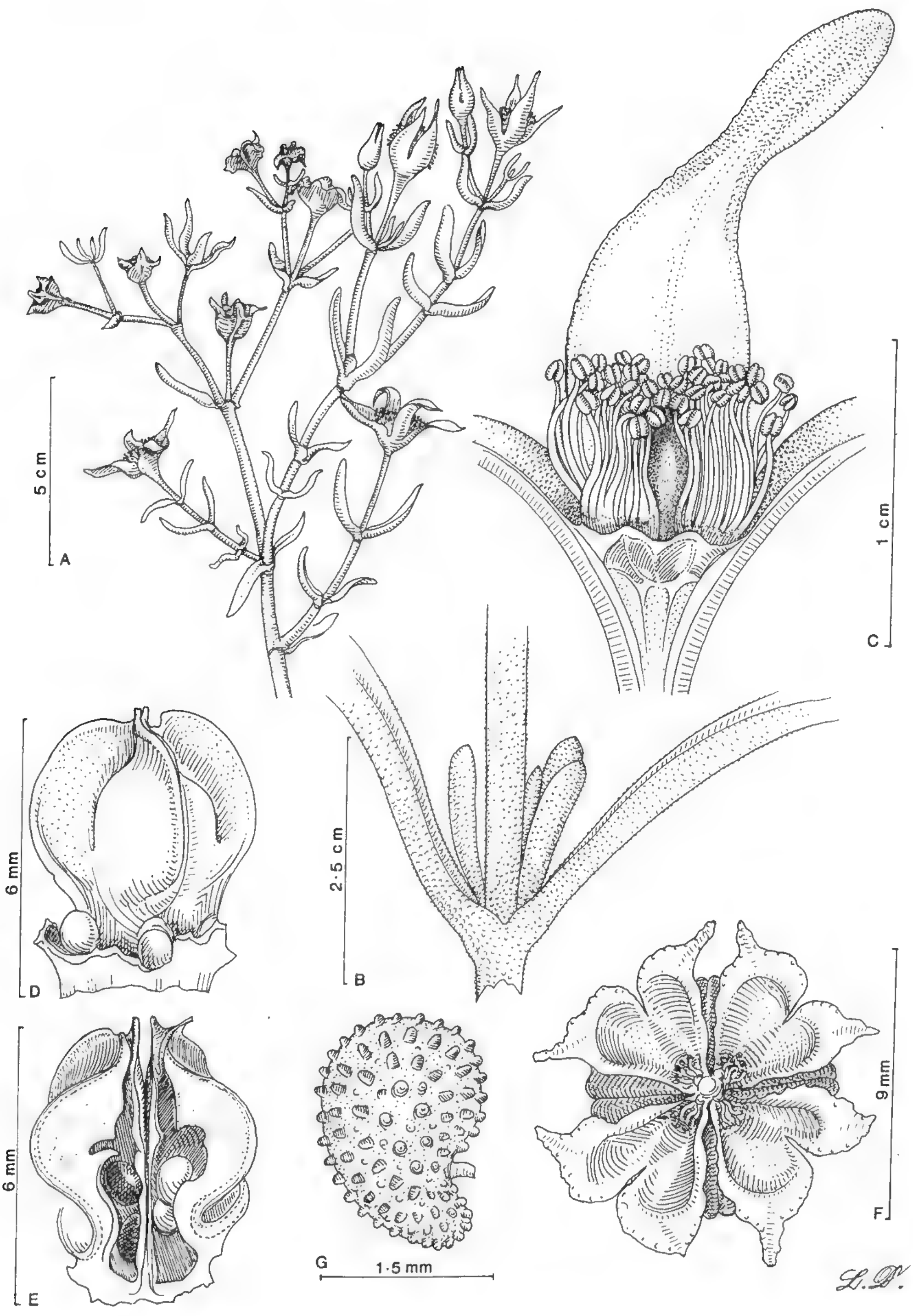


Fig. 36. *Gunniopsis quadrifida*. A, habit; B. enlargement of branch with leaves; C. longitudinal section through the flower to show the stamen bundles; D, lateral view of fruit; E, longitudinal section of capsule; F, opened capsule; G, lateral view of seed (based on *Chinnock 5170*).

Common on outwash plains, along drainage channels and on rises adjacent to salt and freshwater lakes where it often locally dominates or codominates with chenopodiaceous genera such as *Halosarcia*, *Atriplex* and *Maireana*. It occurs on a variety of sandy or clay loam soils, widespread throughout southern Western Australia and South Australia, but localised in the Northern Territory, western Queensland and western New South Wales.

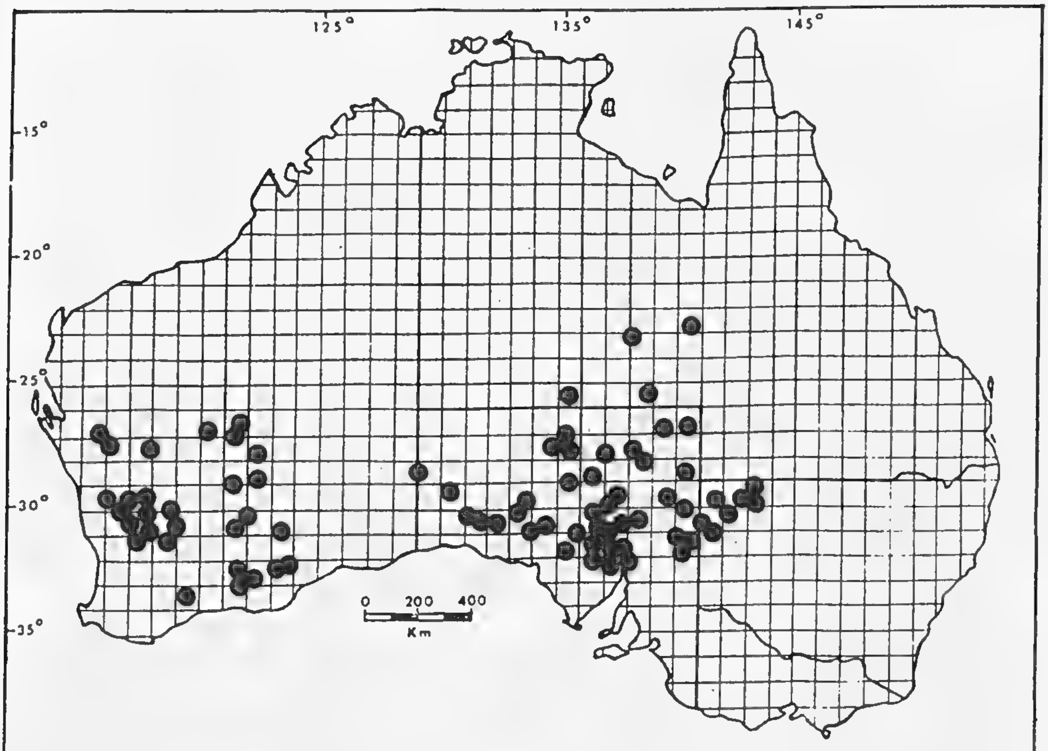
Notes

Although no infraspecific subdivision of this species has been attempted it is acknowledged that the majority of Western Australian populations are more robust than those further to the east. Leaves in these former populations are generally more erect and much longer, ranging from 17-80 mm, while in eastern populations they rarely exceed 15 mm in length although some plants produce leaves up to 28 mm. The size of the flower also varies considerably with Western Australian forms normally being larger. However, small leaf and flower forms do occur randomly in Western Australia, while robust forms with larger flowers and leaves occur occasionally in South Australia.

A population 19 km north of Marla Bore in northern South Australia (*Chinnock 5514*) was found remarkable in that all flowers had consistently pinkish-purple anthers and ovary while they are usually pale yellow and green respectively.

Selected Specimens (collections seen: 198)

WESTERN AUSTRALIA: *A.M. Ashby 2561*, E of Murchison road crossing near Twin Peaks Station, 18.viii.1968 (PERTH, AD); *B.G. Briggs*, 3 miles SE of Morawa, 1.x.1960 (NSW 147633); *R.J. Chinnock 755*, Beru Pool, Yelma Station, 5.ix.1973 (AD); *R.J. Chinnock 5137*, Lake Raeside, 11.3 km S of Leonora, 13.x.1981 (AD); *C.A. Gardner s.n.*, Gilmores, v.1924 (PERTH); *A.S. George 5968*, Ponton Creek, N of Zanthus, 9.xi.1963 (PERTH); *J.W. Green 830*, 5 miles W of Cowcowing Lakes, 4.xi.1956 (PERTH); *J. Young s.n.*, near Mt Churchman, no date, (MEL 99620).



Map 2. Distribution of *G. quadrifida*.

NORTHERN TERRITORY: *N. Forde 788*, 10 miles W of Andado Homestead, 16.iv.1957, (NSW); *T.S. Henshall 1977*, Andado Station Homestead, 17.iv.1977 (AD, NT); *H. Kempe s.n.*, near Charlotte Waters, 1852 (MEL 99609); *W. Schwartz s.n.*, Charlotte Waters, 1889 (MEL 99613); *S.A. White s.n.*, MacDonnell Ranges, no date, (AD 97734342).

SOUTH AUSTRALIA: *R.F. Aiten 6*, Roxby Downs, 15.v.1981 (AD); *R.J. Chinnock 2683, 2684*, Yarle Lakes, 30.ix.1975 (AD); *N.N. Donner 1764*, 65km E of Coober Pedy, 9.ix.1966 (AD); *B.G. Lay 190*, Half Moon Lake, Commonwealth Hill Station, 27.xi.1970 (AD); *K.D. Rohrlach 849*, Lake Gardner on island c. 8 km from shore, south end, 1.i.1962 (AD); *D.E. Symon 12579*, Serpentine Lakes near island S of crossing on Connie Sue Highway, 25.viii.1980 (ADW).

QUEENSLAND: *H. Clarke s.n.*, Mulligan River, ii.1904, (NSW 147630); *A. Henry s.n.*, Georgina River, 1889 (MEL 99610); *M. Olden 761 & D.E. Boyland*, 15 km NNW of Roebucks Tank, 26.v.1978 (AD, BRI); *R.W. Purdie 1154*, 141 km from Birdsville on the new Betoota road, 18.ix.1977 (AD, BRI).

NEW SOUTH WALES: *Beckler s.n.*, near the Barrier Range, 28-29.xii.1861, (MEL 99605, 99606); *J. Campbell & J. Pickard 1258*, 3.5 km N of Turleys Gate, 18.xi.1970 (NSW); *G.M. Cunningham 503*, Delalah Downs, 18.viii.1972, (NSW); *G.M. Cunningham & P.L. Milthorpe 1068*, Cobham Lake, 45 km SE of Milparinka, 16.ix.1973 (NSW); *E.N.S. Jackson 2884*, 28 km ESE of Whyjonta Bore, 12.v.1977 (AD); *S. Jacobs 3047*, Yantara Lake, 5.v.1977 (NSW).

2. **Gunniopsis tenuifolia** Chinnock, sp. nov.

Frutex foliis longis, tenuibus, teretibus, glabris praeter pilis basi marginibus; *floribus* parvis fasciculatis super foliis; *perianthii segmentis* connatis, interne flavovirentibus; *staminibus* fasciculis 4 segmentis alternantibus; filamentis teretibus papillosis; *capsula* ovoidea; *seminibus* ovoideis, atro-brunneis, granulatis.

Type: *R.J. Chinnock 5492*, 22.6 km N of Leigh Creek South, South Australia, 27.i.1982 (holotype: AD; isotypes CANB, K, NSW, NT).

Etymology: Latin *tenuifolius*, slender leaved.

Shrub 0.5-0.9 x 0.5-1.7 m, compact, rounded. *Branches* green to orange-brown turning stramineous, minutely papillose towards tips, smooth in older parts, glabrous. *Leaves* green or brownish-green, at first reddish at base, linear-terete, subterete at base, apex acute, (15-) 28-65 x 0.7-2 mm, glabrous except on margins at base; fascicles of small leaves of shortened lateral branches often in leaf axils along main branches. *Flowers* small, pedicellate, distinctly aggregated into a small terminal inflorescence, leaves subtending the flowers distinctly smaller than on vegetative branches, 6-16 mm long. *Perianth* fused basally; segments almost equal, triangular, acute to acuminate, becoming rigid and spreading at the fruiting stage, 4.5-7.7 x 2.5-4.7 mm; outside surface green to reddish, smooth; inside surface yellow-green, finely papillose. *Stamens* numerous in 3-5 whorls, grouped in four bundles, alternate with perianth segments; filaments terete, papillose; anthers smooth. *Ovary* 4-ribbed, papillose; stigmas smooth. *Capsule* 4-ribbed, 3.5-5.5 x 3.5-6.7 mm; valves when opened emarginate, obtuse. *Seed* 1.4-1.8 x 1.2-1.5 mm, ovoid, blackish-brown, shiny, granulate. (Figs 11, *37*, 38; Map 4).

This species, which is related to *G. quadrifida*, is restricted to South Australia extending from Leigh Creek north-west to the Arkaringa Hills. In the vicinity of Leigh Creek the species grows on stony slopes of low hills but it also extends down on to clay flats and depressions subject to periodic flooding where it dominates or co-dominates with *Halosarcia* species (Fig. 38). Near Hermit Hill NW of Marree the species grows on light-brown clay flats under open mallee woodland. One specimen (*Lay 651*), the species is recorded as growing along erosion channels in shale residuals.

Specimens examined

SOUTH AUSTRALIA: *R.J. Chinnock 5849, 5490*, 22.6 km N of Leigh Creek South, 27.i.1982 (AD); *R.J. Chinnock 5502*, 8.2 km N of Leigh Creek South, 21.ix.1982 (AD); *R.J. Chinnock 5503*; 66.4 km NW of Marree near Hermit Hill, 21.ix.1982 (AD); *B. Lay 651*, Back Mulga Paddock, Millers Creek Station, 13.x.1971 (AD); *T.R.N. Lothian 123*, Leigh Creek, 8 km N of the town towards north field, 29.ix.1959 (AD); *T.R.N. Lothian 2125*, Arckaringa Amphitheatre, c. 80 km SW of Oodnadatta, 15.viii.1963 (AD); *T.R.N. Lothian 4998*, north field, Leigh Creek, 18.x.1968 (AD); *D.E. Symon 11175*, S of Hermit Hill, 2.x.1978 (AD, ADW); *D.E. Symon 11478*, Arckaringa Hills, 21.x.1978 (AD, ADW).

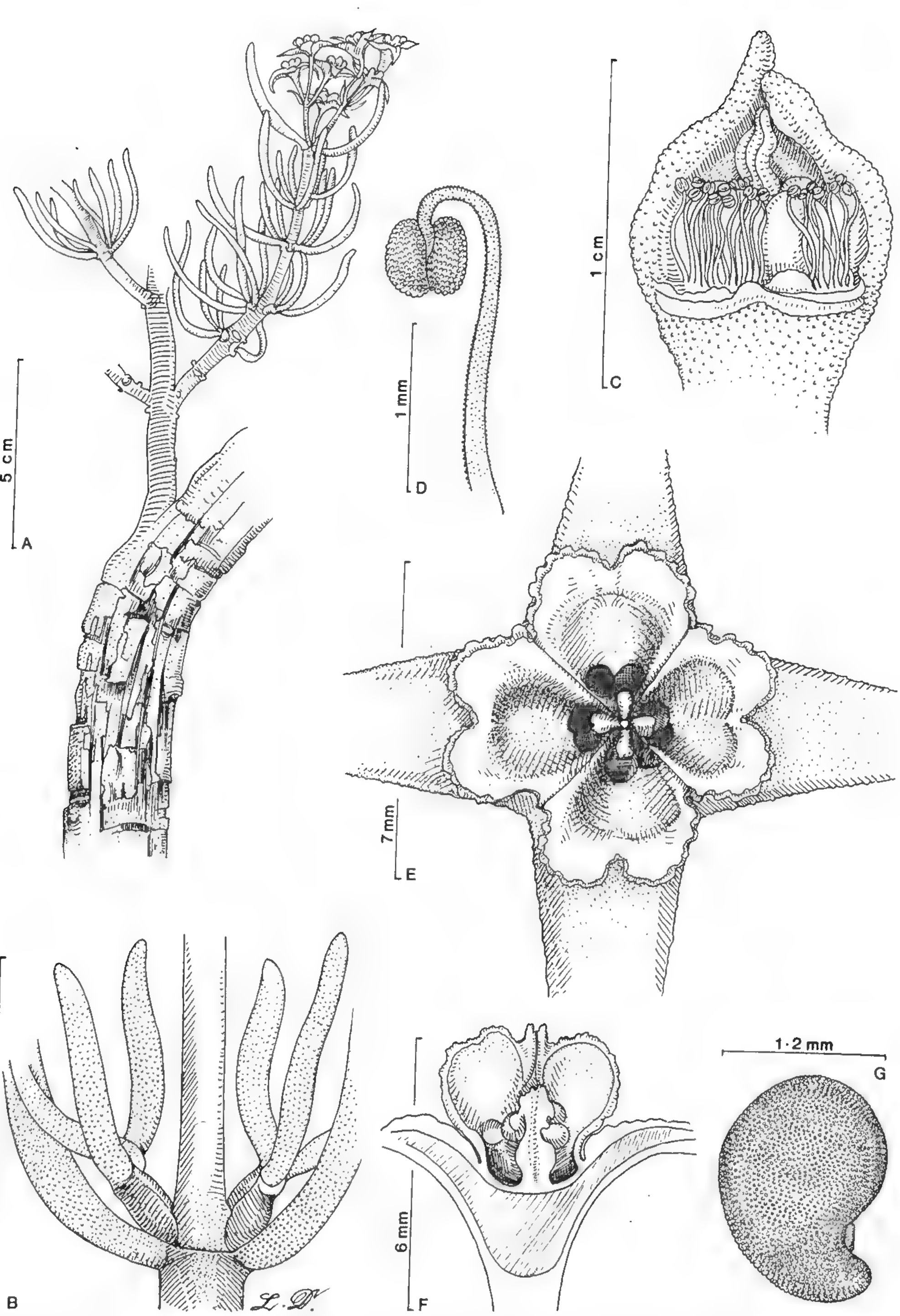


Fig. 37. *Gunniopsis tenuifolia*. A, portion of major stem showing deeply fissured bark and branch with leaves and fruits; B. enlargement of branch; C, longitudinal section through the flower showing the stamen bundles; D, stamen; E, open capsule; F, longitudinal section through capsule; G, lateral view of seed (based on *Chinnock 5489*).

Fig. 38. Stony flats dominated by *G. tenuifolia*, Leigh Creek, South Australia.

3. **Gunniopsis zygophylloides** (F. Muell.) Diels in Diels & Pritzel, Bot. Jahrb. 35: 197 (1904); Maiden & Betche, Cens. N.S.W. Pl. 74 (1916); Black, Fl. S. Aust. edn 1, 221 (1924).

Type citation: "Trans montem Margaret: B. Herschel Babbage".

Type: *B. Herschel Babbage s.n.* (Hergolt)., towards Mt Margaret, (South Australia). 1871 (holotype: MEL 99635).

Aizoon zygophylloides F. Muell., Fragm. 7: 129 (1871); Ewart & Davies, Fl. N. Terr. 106 (1917); Black, Fl. S. Aust. edn 2: 341 (1948) p.p.; Toelken in Jessop, Fl. Cent. Aust. 36 (1981) p.p.

Shrub 15-40 x 15-80 cm, compact. *Branches* green to stramineous, pubescent, hairs succulent, clavate but flattened and plate-like when dry, translucent, crisped. *Leaves* green or yellow-green, ovate to obovate, acute, tapering towards base, base slightly dilated and ± auriculate when dry, 16-60 x 5-31 mm, surface distinctly papillose, moderately clothed, at least when immature, with flattened crisped hairs. *Flowers* scattered along flowering branches, pedicellate. *Perianth* fused basally; segments almost equal, triangular, acute, 7.5-14 x 3-7.3 mm; outside surface green, sparsely clothed with flattened crisped hairs; inside surface yellow, minutely papillose. *Stamens* numerous, in 2 or 3 whorls, evenly distributed around the ovary; filaments dilated and flattened in lower part, terete in upper part and minutely papillose; anthers smooth. *Ovary* prominently 4-ribbed and depressed at apex, papillose; stigmas papillose. *Capsule* prominently 4-lobed, deeply depressed at apex, (3.5-) 5-8 x (3.2-) 4.5-8.5 mm; valves when open cucullate, emarginate. *Seed* 1-1.2 x 0.8-1 mm ovoid, black, colliculate. (Fig. 39; Map 3).

Unlike most species of *Gunniopsis*, which favour saline sites, *G. zygophylloides* occurs in rocky situations in ranges and on shaly or quartzite residuals of Central South Australia and southern Northern Territory. More rarely this species occurs on gibber flats or in gravel along river courses, e.g. Finke River.

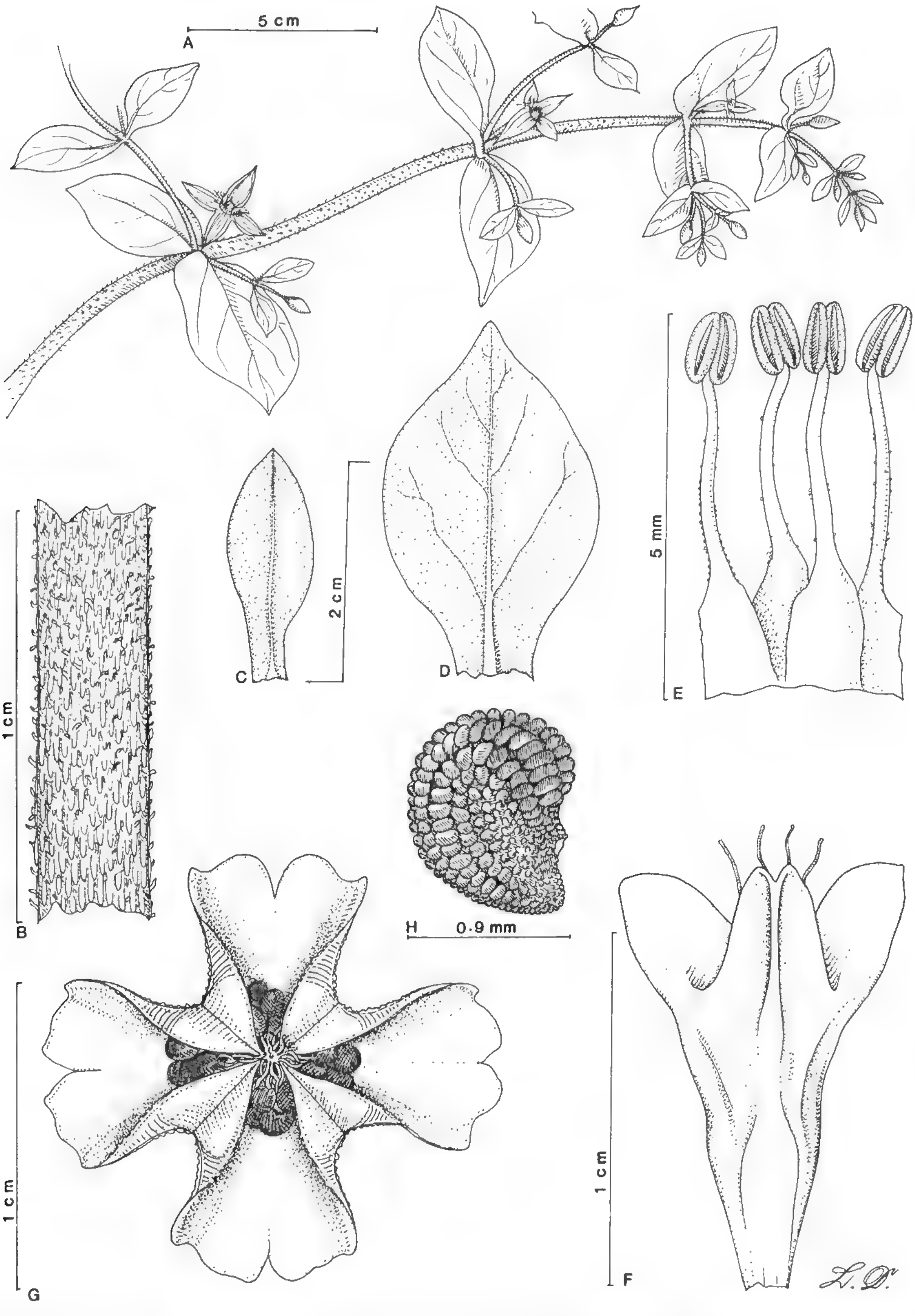


Fig. 39. *Gunniopsis zygophylloides*. A, habit of prostrate branch; B, enlargement of branch; C-D, variation in leaves; E, stamens showing the flattened bases; F, lateral view of capsule; G, opened capsule; H, lateral view of seed (A, B, D, *Munir 5077*; E-H, *Pastoral Board of South Australia* AD 97912199; C, *Chinnock 2564*).

Selected specimens (collections seen: 47).

NORTHERN TERRITORY: *G. Chippendale s.n.*, Henbury, 5.viii.1954 (AD, NSW, NT); *G. Chippendale s.n.*, 1.4 m N of Horseshoe Bend, 11.x.1957 (AD, NSW, NT); *P. Hooper s.n.*, First Bore, Victory Downs Station, 9.vii.1967 (AD); *P.K. Latz 248*, 19 m W of Henbury, 9.xii.1968 (AD); *T.R.N. Lothian 704*, near Finke River, Henbury Station, 1954 (AD); *W. Schwartz s.n.*, Charlotte Waters, 1889 (MEL 99645); *R. Tate s.n.*, Chandlers Range, no date (AD 97109458).

SOUTH AUSTRALIA: *R.J. Chinnock 2564*, 10 km WNW of Hogarth Hill, 25.ix.1975 (AD); *R.J. Chinnock 5513*, 9.5 km E of Mt Willoughby on the Copper Hills road, 22.ix.1982 (AD); *N.N. Donner 1706*, 58 km N of Kingoonya, 8.ix.1966 (AD); *E.H. Ising s.n.*, Evelyn Downs, 6.viii.1955 (AD 97608467); *R.W. Jessup s.n.*, Miller's Creek Station, Spring, 1950 (ADW 6827); *B. Lay 661*, 10 km N of Bon Bon Homestead, 16.x.1971 (AD); *T.R.N. Lothian 2681*, "8 mile digging": Coober Pedy, 2.v.1964 (AD); *D.E. Symon 11481*, Arckaringa Hills, 21.x.1978 (ADW).

4. **Gunniopsis calcarea** Chinnock, sp. nov.

G. quadrifida var. *zygophylloides* sensu Blackall & Grieve, West Aust. Wildfls 1: 163 (1954).

G. zygophylloides sensu Gardner, Enum. Pl. Aust. Occid. 2: 42 (1930).

Frutex perennans ramis foliis pedicellis et segmentis perianthii lepidotis; *foliis* carnosis lanceolatis; *perianthii segmentis* connatis anguste lanceolatis interne citrinis; *staminibus* aequaliter distributis circum ovarium; filamentis manifeste infra alatis; *capsula* 4-valvi valvis manifeste elevatis acutis cucullatis ubi apertis apexibus bifidis; *seminibus* ovoideis colliculosis.

Type: *R.J. Chinnock 5086*, 4.2 km NW of Eucla, Western Australia, 7.x.1981 (holotype: AD; isotypes BRI, CANB, K, MEL, NSW, NT, US).

Etymology: Latin *calcareus*, limestone; alluding to the restriction of this species to the Nullarbor Plain on skeletal calcareous soils.

Shrub 10-20 x 10-80 (-140) cm, compact. *Branches* densely white lepidote but older woody branches often ± glabrous; scales appressed, margins irregularly branched. *Leaves* bright green or yellow-green, fleshy, linear-lanceolate to lanceolate, tapering to base, apex acute, 8-28 x 1.7-4.5 mm, densely white lepidote when immature but soon becoming sparsely lepidote. *Flowers* pedicellate. *Perianth* fused basally; segments almost equal, narrowly triangular, acute, 3.5-8 x 1.7-4 mm; outside surface green but turning reddish after flowering, sparsely to densely lepidote; inside surface yellow, papillose. *Stamens* numerous, in 2 or 3 whorls, evenly distributed around the ovary; filaments flattened in lower part, terete in upper part, papillose; anthers papillose. *Ovary* shallowly 4-ribbed in upper part, depressed at apex, papillose; stigmas smooth. *Capsule* 4-lobed, 4-7 x 3-6.7 mm; valves acute, when opened cucullate, with apex emarginate. *Seed* 1-1.1 x 0.8-1 mm, ovoid, dark brown to blackish-brown, colliculate. (Figs 13, 29, 30, 31, *40*; Map 3).

Gunniopsis calcarea is restricted to the Nullarbor where it grows on skeletal calcareous brown earths, especially in shallow depressions with *Halosarcia* and *Maireana* species where it often co-dominates with them. It also occasionally occurs in open places in low mallee-*Melaleuca* scrubland.

Notes

There is one mixed collection at PERTH consisting of *G. calcarea* and *G. quadrifida* which was collected at Gilmores (SW of Norseman) by Gardner. This record of *G. calcarea* is discounted for two reasons. Firstly, Gardner stated that the flowers were white which is obviously a reference to *G. quadrifida*. Secondly, the range; *G. calcarea* stops abruptly just east of Balladonia on the edge of the Nullarbor and it is not known to occur from any locality further west. Gardner collected *G. calcarea* two days after his visit to Gilmores, east of Balladonia, so that it seems likely that a specimen became mixed in with his Gilmores collection of *G. quadrifida*.

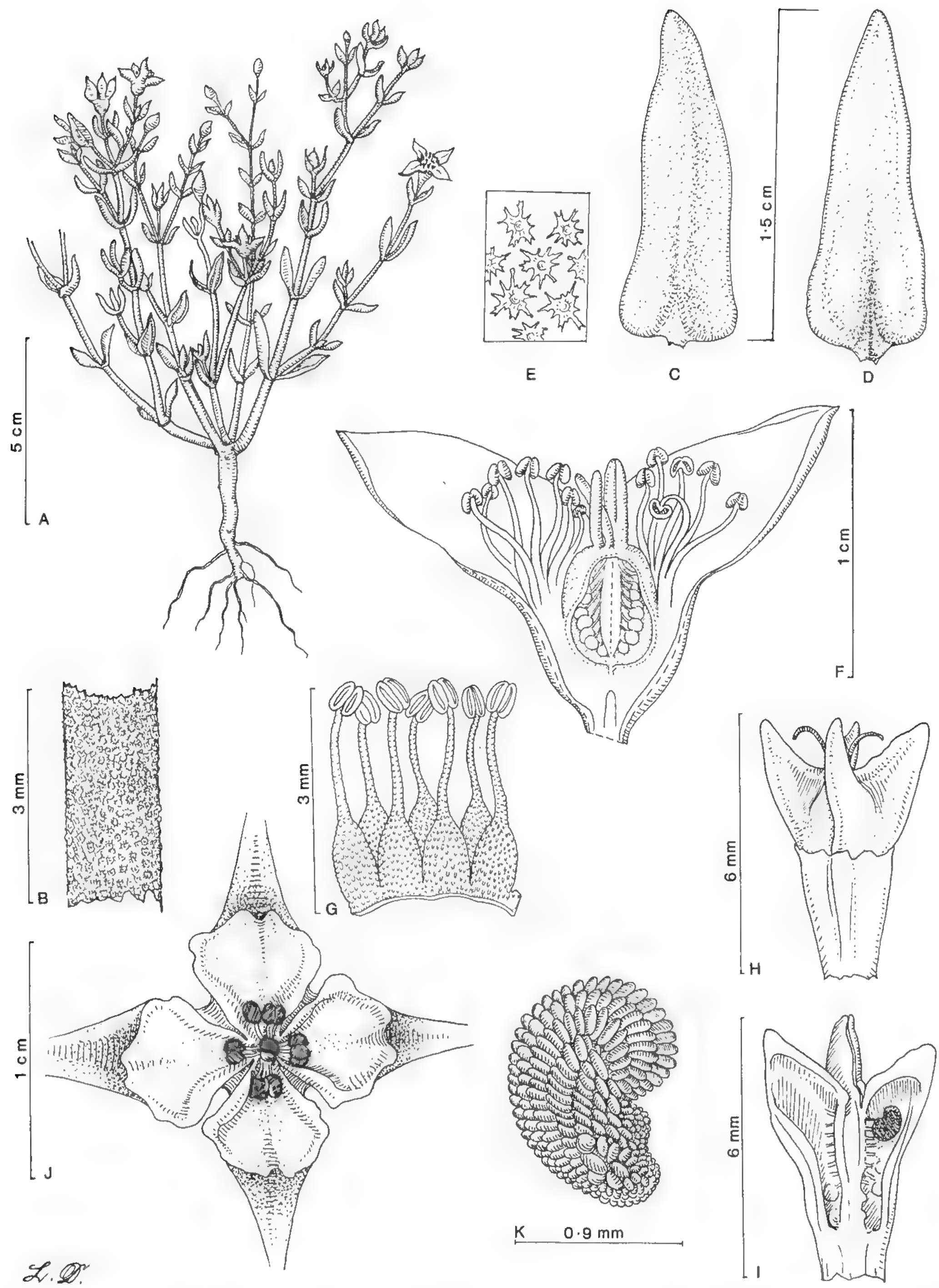
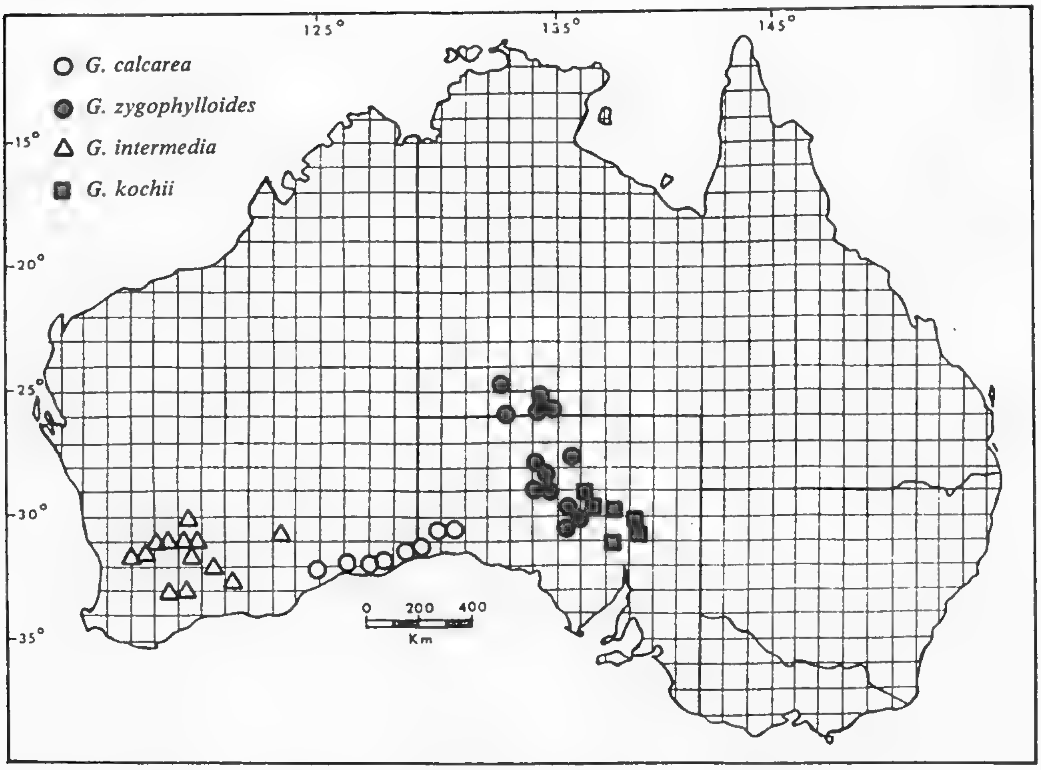


Fig. 40. *Gunniopsis calcarea*. A, habit of small plant; B, enlargement of branch showing clothing of scales; C-D, lower and upper side of leaf respectively; E, enlargement of leaf surface to show details of scales; F, longitudinal section through flower; G, group of stamens; H, lateral view of capsule; I, longitudinal section through capsule; J, open capsule; K, lateral view of seed (based on *Chinnock 5468*).



Map 3. Distribution of *G. calcarea*, *G. intermedia*, *G. kochii* and *G. zygophylloides*.

Selected specimens (collections seen: 36)

WESTERN AUSTRALIA: *J.D. Batt s.n.*, Eucla, 1889 (MEL 99631); *R.J. Chinnock 3345*, 3.2 km NNW of Eucla Motel, 12.x.1976 (AD, PERTH); *R.J. Chinnock 5464*, 46.6 km W of Caiguna, 8.xi.1981 (AD); *R.J. Chinnock 5466*, 2.6 km E of Madura, 9.xi.1981 (AD); *C.A. Gardner & W.E. Blackall 1212*, near Balladonia, 29.x.1931 (PERTH); *P.G. Wilson 5819*, 5 km W of Cocklebiddy, 17.v.1967 (PERTH).

SOUTH AUSTRALIA: *B.G. Briggs s.n.*, 21 miles E of Eucla, 27.ix.1960 (NSW 147629); *R.J. Chinnock 5470*, 25.2 km E of the SA/WA border, 9.xi.1981 (AD); *D.E. Symon 4492*, Koonalda Cave, 16.ii.1967 (ADW); *D.J.E. Whibley 660*, 2 km W of Cook, 16.ix.1960 (AD).

5. **Gunniopsis intermedia** Diels in Diels & Pritzel, Bot. Jahrb. 35: 197 (1904); Gardner, Enum, Pl. Aust. Occid. 2: 42 (1930); Erickson et. al., Fls & Pl West. Aust. 122 (1973).

Type citation: "Herb. in distr. Coolgardie australi pr. Gilmores in eucalyptetis lapidoso-lutosis (subnitrosis?) flor. m. Nov. (D. 5462)".

Type: *Diels 5462*, Gilmores, W. Australia, 6.xi.1901 (holotype: B, destroyed; isotype: MEL 99601).

Herb 3-25 x 3-50 cm, erect or prostrate. *Branches* when fresh green to red-brown, shiny, smooth, becoming stramineous and longitudinally striated when dry. *Leaves* bright green to brownish-green, oblong, oblanceolate to spathulate, obtuse, slightly channelled above, dilated at base and ± auriculate, 21-72 x 3.2-20 mm, smooth, shiny. *Flowers* pedicellate. *Perianth* fused basally; segments narrowly triangular, acute, 5.7-9.8 x 2-4 mm; outside surface green to yellow-green, smooth; inside surface bright yellow

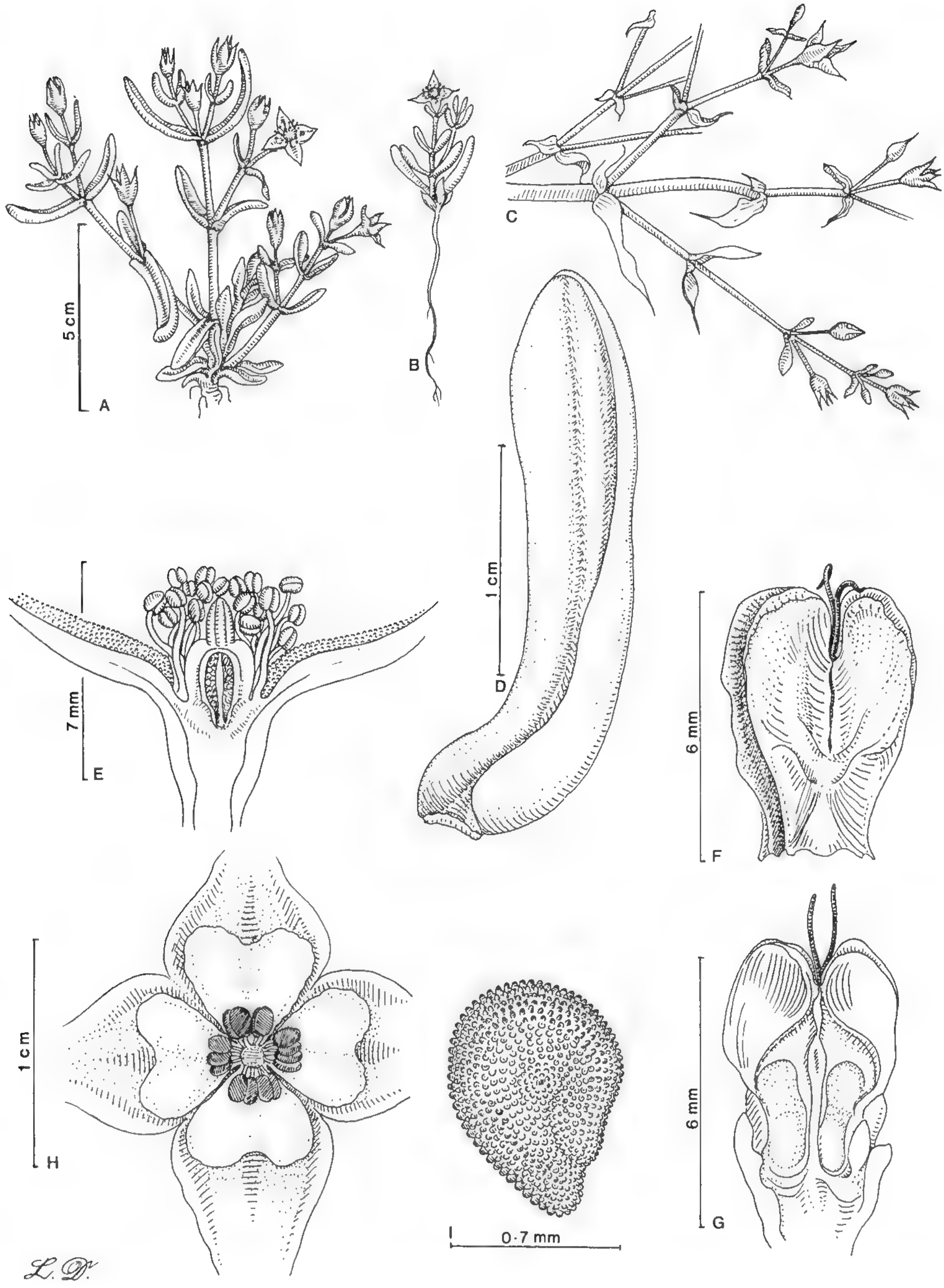


Fig. 41. *Gunniopsis intermedia*. A, small plant; B, depauperate plant; C, prostrate branch of large plant; D, leaf; E, longitudinal section of freshly opened flower; F, lateral view of fruit; G, longitudinal section through capsule; H, open capsule; I, lateral view of seed (based on *Chinnock 5406*).

eventually fading to white, minutely papillose. *Stamens* numerous, in 2 whorls, evenly distributed around ovary; filaments flattened in lower part, terete in upper part, minutely papillose; anthers minutely papillose. *Ovary* prominently 4-ribbed, smooth; stigmas papillose. *Capsule* prominently 4-winged, depressed at apex, 3.5-5.5 x 3.3-4.8 mm; valves when open cucullate, emarginate. *Seed* 0.8-1 x 0.6-0.8 mm, broadly ovoid, dark blackish-brown, finely tuberculate. (Figs 5, 6, 18, 41; Map 3).

Gunniopsis intermedia is commonly found on flats and sandy rises around the margins of salt lakes often in open *Melaleuca* or *Eucalyptus* shrubland or on the upper edges of *Halosarcia* low shrubland. Widespread throughout the Roe, Avon and Coolgardie Botanical Districts of Western Australia.

Selected specimens (collections seen: 23)

WESTERN AUSTRALIA: *W.E. Blackall 981*, 48 km E of Southern Cross, 9.x.1931 (PERTH); *R.J. Chinnock 4360*, Eclipse Lake, c. 12 km NW of Lake Biddy, 11.xi.1978 (AD); *R.J. Chinnock 4416 and P.G. Wilson*, Mortlock River just E of Meckering, 22.xi.1978 (AD); *N.N. Donner 1367*, 69 km WSW of Kalgoorlie, 29.ix.1965 (AD); *W.V. Fitzgerald s.n.*, Cunderdin, xi.1903 (NSW 147623, PERTH); *A.S. George 5909*, Ponton Creek, N of Zanthus, 22.ix.1963 (PERTH); *H.R. Toelken 6515*, NE end of Lake Johnston, 9.x.1979 (AD).

6. **Gunniopsis papillata** Chinnock, sp. nov.

Gunniopsis zygophylloides sensu Black, Fl. S. Aust. edn 1. 221 (1924), p.p.

Aizoon zygophylloides sensu Black, Fl. S. Aust. edn 2. 341 (1948, 1963) p.p.; Toelken in Jessop, Fl. Cent. Aust. 37 (1981) p.p.; Jacobs & Pickard, Pl. NSW. 61 (1981); Cunningham et al., Pl. West. N.S.W. 292 (1982).

Planta herbacea ramis erectis vel prostratis; ramis pubescentibus raro glabris; *foliis* oblongis ad oblanceolatis, obtusis, papillosis vel glabris; *perianthii segmentis* connatis, internis albis vel citrinis; *staminibus* numerosis aequilater distributis circum ovarium; filamentis glabris infra complanatis; *capsula* 4-lobata; *seminibus* ovoideis fere circularibus, atro brunneis, subtiliter tuberculatis.

Type: *J.Z. Weber 5747*, 10 km S of Curdamurka along the creek to Stuart Creek Homestead, South Australia, 3.x.1978 (holotype AD; isotypes BRI, K, MEL, MO, NSW, P, PERTH, PRE, NT, US).

Etymology: Latin *papillatus*, having papillae; alluding to the papillae which cover the branches and leaves.

Herb 2-10 x 2-70 cm, erect or prostrate. *Branches* pubescent at least towards the branch tips or rarely glabrous, hairs clavate, succulent, drying flat and crisped. *Leaves* green, oblong to oblanceolate, obtuse, (9.5-) 18-36 x 2.5-12 mm, papillose to rarely almost smooth. *Flowers* pedicellate. *Perianth* fused basally; segments ovate to triangular, acute, 4.4-9.5 x 2.3-4.9 mm; outside surface green, papillose; inside surface yellow or white, papillose. *Stamens* numerous, in 2-3 whorls, evenly distributed around ovary; filaments terete, or flattened in lower part in the outermost whorls, papillose; anthers minutely papillose. *Ovary* 4-ribbed, papillose; stigmas papillose. *Capsule* 4-lobed, depressed at apex, 4.7-7 x 4.5-5 mm; valves when open bifid. *Seed* 0.9-1.1 x 0.7-0.9 mm, ovoid to almost circular, dark brown, finely tuberculate. (Figs 15, *42*; Map 6).

This species is usually found along ephemeral creek beds, swales and in depressions on gibber flats on saline loams or clays where it often dominates. It is particularly common in central South Australia and also occurs in the extreme NW of New South Wales and from a few scattered localities in Queensland. There are two old records from Charlotte Waters in the Northern Territory.

Notes

The colour of the perianth in this species appears to be either white or yellow. Although reference to pink forms has been made on some herbarium labels from South

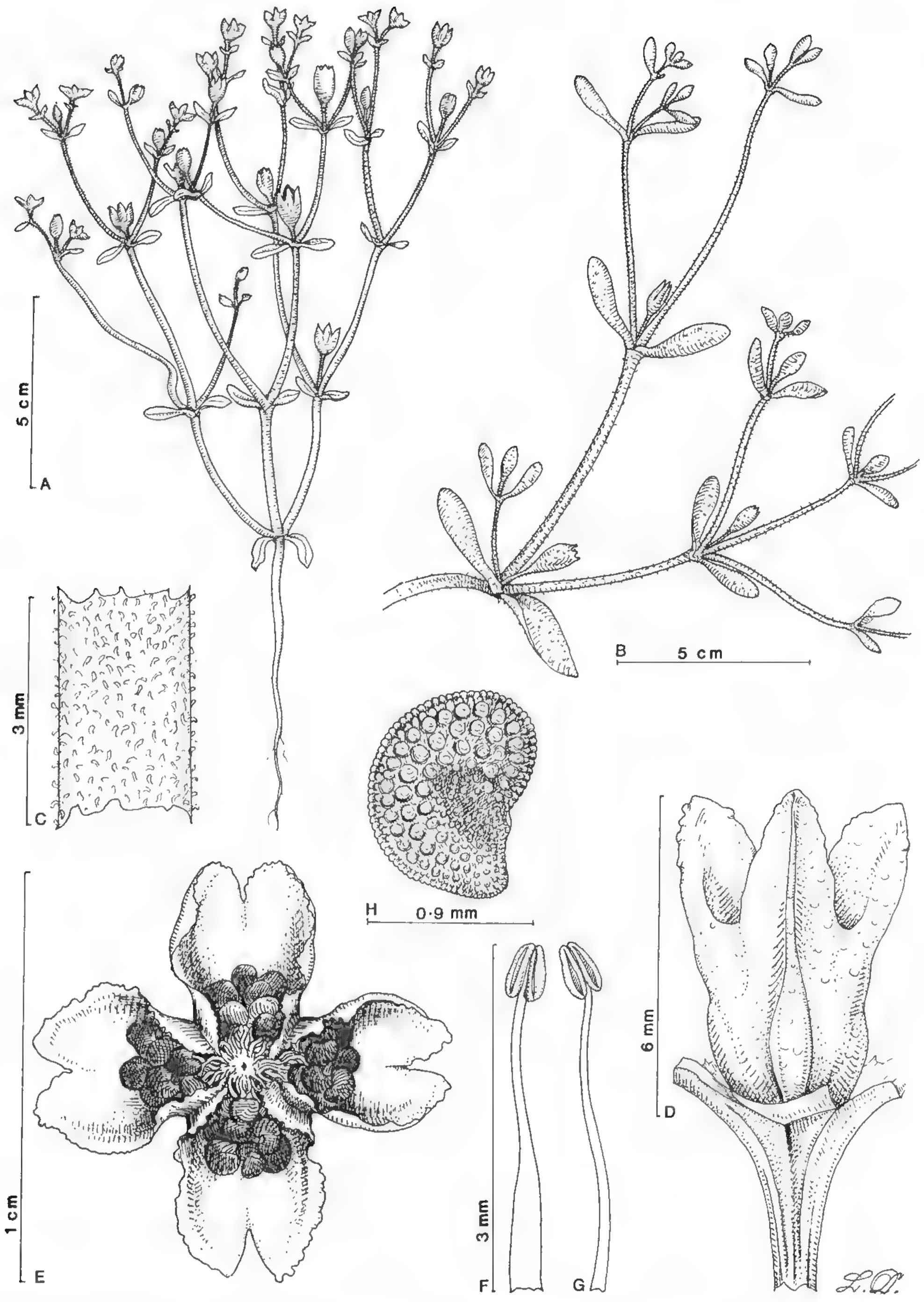


Fig. 42. *Gunniopsis papillata.* A, habit of small plant; B, prostrate branch of large plant; C, enlargement of branch; D, lateral view of capsule; E, open capsule; F-G, stamens of inner and outer whorl respectively; H, lateral view of seed (A, C-H, *Weber 5747*, B, *Lothian 1295*).

Australian localities, it is thought that these probably refer to plants of *Gunniopsis kochii* which is vegetatively very similar and occurs sympatrically with *G. papillata* in the south-eastern part of its range.

Forms of this species, with glabrous branches although uncommon, occur occasionally in the northern parts of South Australia and in the vicinity of Mt Isa in Queensland. These plants also lack the prominent papillae which cover the leaves of the typical form and the tubercles on the seed testa are not as pronounced.

Selected specimens (collections seen: 54)

NORTHERN TERRITORY: *H. Kempe 44*, near Charlotte Waters, 1885 (MEL 99647); *W. Schwartz s.n.*, Charlotte Waters, 1889 (MEL 99648).

SOUTH AUSTRALIA: *N.T. Burbidge & M. Gray s.n.*, Hawks Nest Tank to Wintinna, 9.x.1955 (CANB 4613); *K. Chorney 926*, 15 km SE of Coward Springs, 2.x.1978 (AD); *B. Copley 2195*, 8 km E of Anna Creek, 3.ix.1968 (AD); *N.N. Donner 1745*, 16 km E of Coober Pedy, 8.ix.1966 (AD); *E.H. Ising s.n.*, Evelyn Downs, 13.x.1953 (AD 97608475); *M. Koch 224*, Mt Lyndhurst, x.1898 (AD, HO, NSW); *R. Schodde 971*, c. 15 km W of Leigh Creek, 12.x.1958 (AD); *D.E. Symon 9345*, Dalhousie Springs, 23.ix.1974 (ADW).

QUEENSLAND: *Dr Morgan s.n.*, Diamantina River, viii.1930 (AD 968071005); *R.T. Perry 1*, Boulia—Mt Isa, 13.viii.1974 (BRI); *A. Tully s.n.*, Quilpie, ix.1955 (BRI 277088).

NEW SOUTH WALES: *W. Baurber s.n.*, near Wilcannia, 1887 (MEL 99638); *G.M. Cunningham & P.L. Milthorpe 1163*, Olive Downs, c. 35 km N of Tibooburra, 18.ix.1973 (NSW); *P. Johncock s.n.*, Mt Wood to Harton Park, 16.viii.1967 (NSW 147618); *A. King s.n.*, near Barrier Range, 1887 (MEL 99639); *J. Nobel W684*, Mt King near Tibooburra, x.1973 (NSW); *R.A. Perry 5726*, Mt King Station, 2.ix.1971 (NSW); *J. Pickard s.n.*, 1.5 km E of Gumhole Tank, 35 km NW of Tibooburra (NSW).

7. **Gunniopsis kochii** (Wagner) Chinnock, comb. nov.

Aizoon kochii Wagner, Ann. Naturhist. Hofmus. 19: 80 (1904); Toelken in Jessop, Fl. Cent. Aust. 36 (1981).

Type: *M. Koch 354*, Mt Lyndhurst, South Australia, Oct. 1898. (holotype W†; isotypes AD, MEL, NSW, PERTH).

Herb 10-25 x 15-30 cm, erect or prostrate, papillose. *Branches* green, prominently papillose or sparsely pubescent, hairs succulent, clavate. *Leaves* green, oblong to oblanceolate, obtuse, 10-25 (-47) x 3-9 (-15) mm, papillose or rarely with scattered succulent clavate hairs on margin. *Flowers* pedicellate. *Perianth* fused basally; segments ovate to triangular, acute, 5-9 x 3-5.2 mm, green outside, prominently papillose, pink inside, minutely papillose. *Stamens* numerous in 2-3 whorls, evenly distributed around ovary; filaments terete or distinctly flattened in lower part in outer whorls, glabrous; anthers smooth. *Ovary* 4-ribbed, papillose; stigmas papillose. *Capsule* prominently 4-lobed, depressed at apex; valves when first opened becoming deeply bifid. *Seed* 0.5-0.7 x 0.4-0.6 mm, ovoid, laterally expanded into curved lobes mainly towards apex, colliculate, cells arranged in rows. (Figs. 12, *43*; Map 3).

G. kochii is restricted to the Lake Eyre, Gairdner-Torrens and Flinders Ranges regions of South Australia where it occurs on stony soils, especially on gibber plains although one specimen (*Symon 11214*) was collected on sandy drifts in a subsaline creek bed.

Notes

Black (1924, 1948) confused this species with *G. papillata* (*G. zygophylloides* sensu Black) largely because these two species are vegetatively almost identical. It was, therefore, natural for him to assume that the perianth of *G. kochii* was merely a colour variant. The two species can be easily separated on their seed.

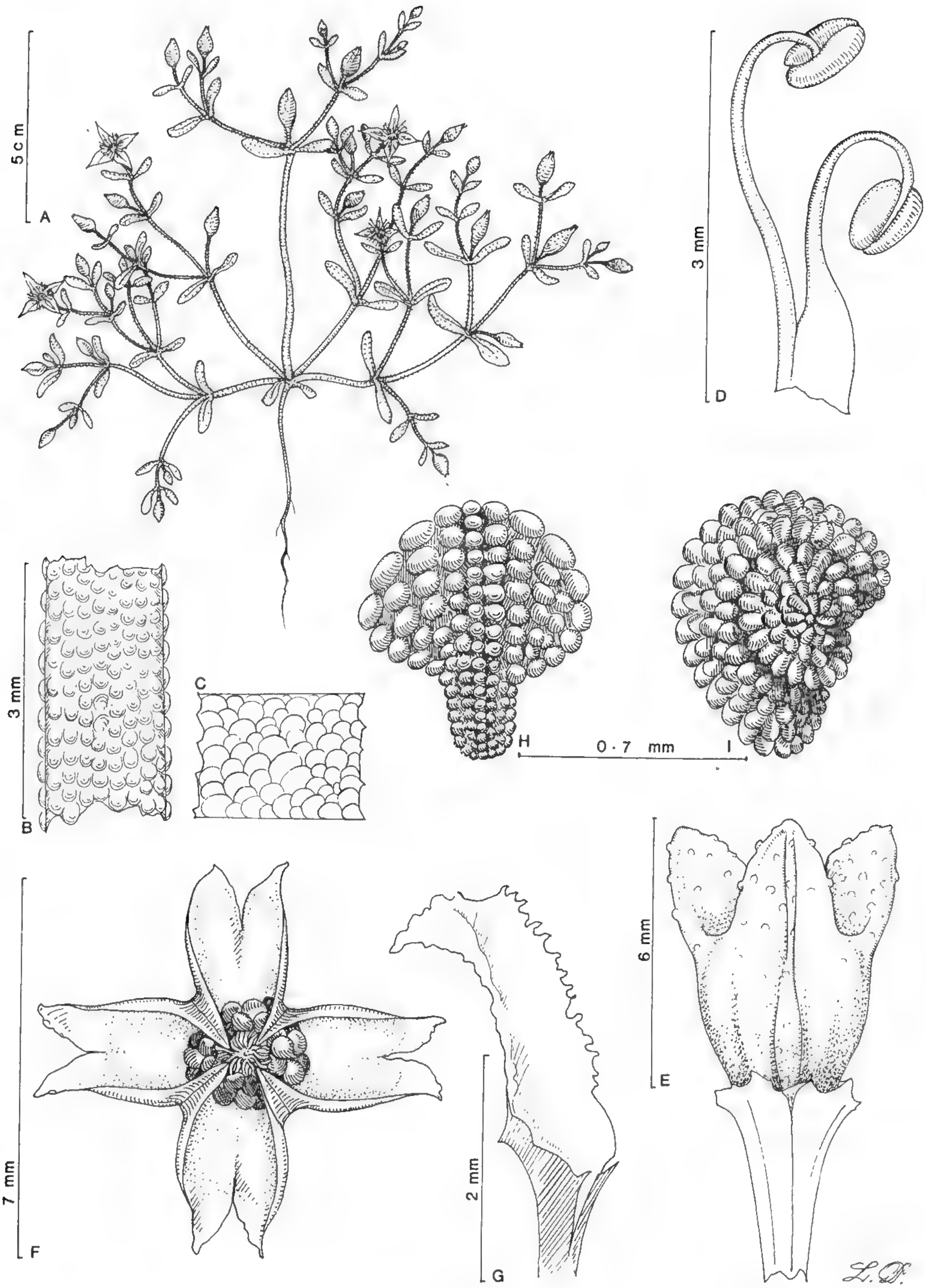


Fig. 43. *Gunniopsis kochii*. A, habit of plant; B-C, enlargement of branch and leaf respectively to show the prominently papillose epidermal cells; D, stamens; E, lateral view of capsule; F, open capsule; G, portion of valve to show the serrate expanding keel; H-I, distal and lateral views of seed (A, D, E-G, *Chorney 995*; B-C, *Symon 11161*; H-I, *Koch 354*).

Specimens examined

SOUTH AUSTRALIA: *F. Badman 261*, 3 km E of Curdimurka, 12.vii.1980 (AD); *K. Chorney 995*, Beresford Hill, 4.x.1978 (AD); *B. Copley 2214*, 6 km SW of Coward Springs, 3.ix.1968 (AD); *Hj. Eichler 12979*, between Leigh Creek and Copley, 3 km S of Leigh Creek, 26.ix.1956 (AD); *R. Hill 327*, Leigh Creek on railway, 1.viii.1955 (AD); *P. Horton 181*, near Hermit Hill Springs, 3.x.1978 (ADW); *T.R.N. Lothian 1429*, 4 miles W of Leigh Creek, 15.ix.1955 (AD); *R.L. Rodgers s.n.*, Coward Springs, 2.ix.1910 (NSW 147621); *R. Schodde 970*, 4 km NW of Copley near Leigh Creek, 12.x.1958 (AD); *R. Swinbourne 91*, Salt Creek, Carrapateena Arm, Lake Torrens, 5.ix.1968 (AD); *D.E. Symon 11131*, Strangways Springs, 1.x.1978 (AD, ADW); *D.E. Symon 11264*, Coward Springs 3.x.1978 (AD); *J.Z. Weber 1320*, Salt Creek, Carrapateena Arm, Lake Torrens, 5.ix.1968 (AD).

8. **Gunniopsis calva** Chinnock, sp. nov.

Planta herbacea ramis foliisque glabris saepe pustulatis crystallis epidermalibus salis protrudentibus; *foliis* oblanceolatis vel obovatis; *perianthii segmentis* connatis interne albis; *staminibus* aequilater distributis; circum ovarium; filamentis infra complanatis; *capsula* 4-valvi; valvis profunde bifidis; *seminibus* ovoideis, brunneis dilutis nitidis colliculosis.

Type: *Hj. Eichler 18818*, Sweet Nell Mines c. 5 km ENE of Woocalla Railway Station Siding, South Australia, 22.x.1966 (holotype: AD; isotype: CANB).

Etymology: Latin *calvus*, hairless, smooth; referring to the smooth branches and leaves of this species.

Herb 3-15 x 3-25 mm, erect or prostrate, glabrous. *Branches* green, smooth, striate when dry, often irregularly pustulate due to crystalline salt protruding from epidermal and sub-epidermal layers. *Leaves* green, oblanceolate, obovate to spathulate, obtuse, 10-35 x 3-12 mm, basal ones often slightly larger than those on the flowering branches, smooth or with scattered crystalline salt pustules. *Flowers* pedicellate. *Perianth* fused basally; segments triangular, equal or two segments longer with terete tips, apex acute, 4.5-13 x 3.5-6.5 mm; outside surface green, smooth; inside surface white, finely papillose. *Stamens* numerous, in 2-3 whorls, evenly distributed around ovary; filaments flattened in lower part, pubescent with hairs clavate; terete in upper part, glabrous; anthers smooth. *Ovary* shallowly 4-ribbed, smooth; stigmas crested. *Capsule* 4-lobed, 4-8 x 4-5.5 mm, when closed deeply depressed at apex between valves; valves when open deeply bifid almost to base so that capsule appears 8-valved. *Seed* 0.5-0.7 x 0.4-0.6 mm, ovoid; pale brown, shiny, colliculate, the cells arranged in rows. (Figs 8, *44*; Map 4).

Common around the margins of salt lakes on northern Eyre Peninsula and in the Gairdner-Torrens region of South Australia.

Specimens examined

SOUTH AUSTRALIA: *Benbow 3*, Tarcoola, 31.x.?1976 (AD); *R.J. Chinnock 392*, West shore of Lake Hart, 17.viii.1973 (AD); *P.E. Conrick 287*, Nonning, 7.xi.1979 (AD); *Hj. Eichler 17627*, southern end of Lake Hart, 21.ix.1963 (AD); *B. Flounders 5*, Lake Gilles, 1967 (AD); *E.N.S. Jackson 537*, Lake Hart, 5.ix.1963 (AD); *R.L. Specht & B.B. Carrodus 110*, 55 km N of Nonning Homestead, 16.xi.1958 (AD); *J.Z. Weber 2890*, 20 km E of Wilgena Station, 30.ix.1971 (AD).

9. **Gunniopsis divisa** Chinnock, sp. nov.

Aizoon glabrum Luehm. ex Ewart, Proc. Roy. Soc. Vic. n.s. 20: 128 (1908) p.p. as to the *Tyson* syntype of *A. glabrum* which is here designated as type of *G. divisa*.

Planta herbacea ramis foliisque glabris; *perianthii segmentis* fere liberis, internis albis; *staminibus* aequiliter distributis circum ovarium; filamentis teretibus, infra hirsutis; *capsula* ovoidea; *valvis acutis*; *seminibus* ovoideis aspectu laterali in lobis curva lateraliter expansis, colliculosis.

Type: *I. Tyson 3*, Murchison River, 1898 (holotype: MEL 99600; isotypes: MEL 99597, MEL 99599, NSW 147627, K).

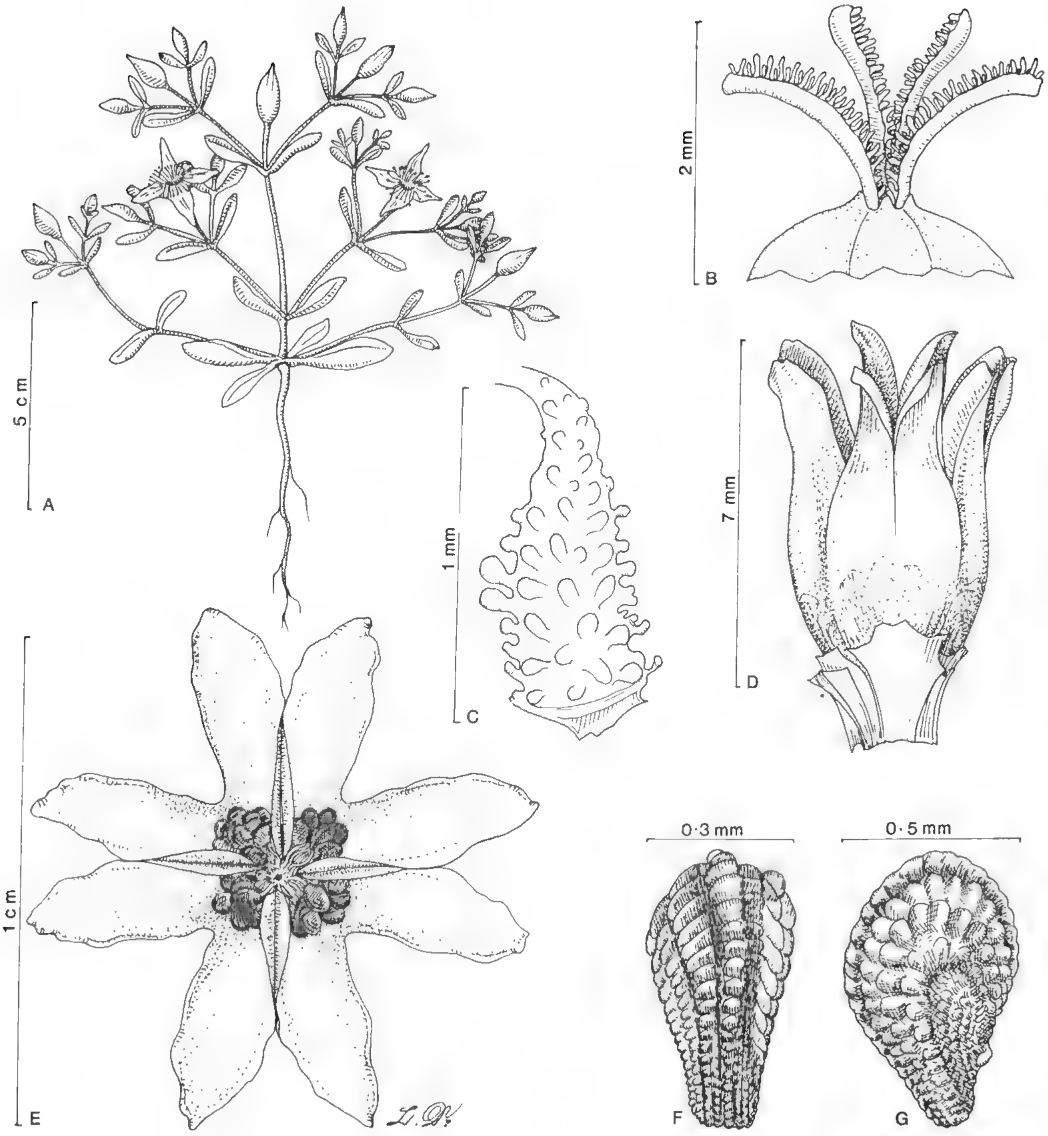
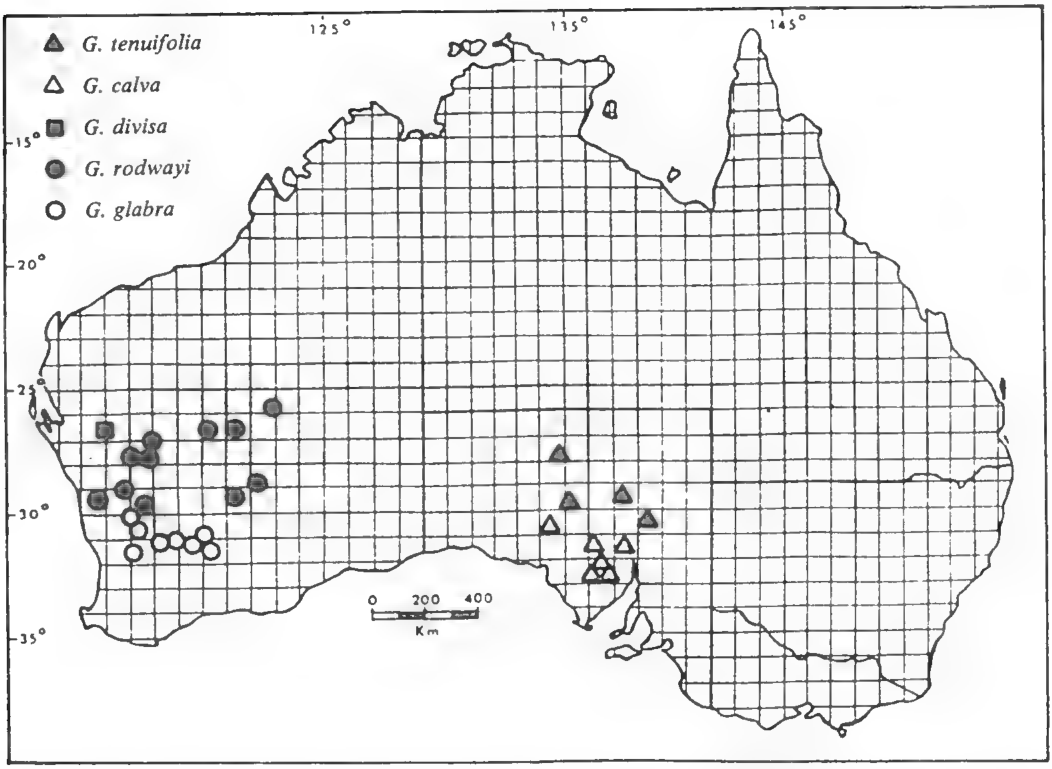


Fig. 44. *Gunniopsis calva*. A, habit of plant; B, prominently crested stigmas; C, base of filament; D, lateral view of capsule; E, open capsule; F-G, distal and lateral views of seed (A-C, *Jackson 537*; D-G and *Specht & Carrodus 110*).



Map 4. Distribution of *G. calva*, *G. divisa*, *G. glabra*, *G. rodwayi* and *G. tenuifolia*.

Etymology: Latin *divisus*, divided; referring to the perianth segments which are divided to the base.

Herb 5-10 x 10-15 cm, with erect and prostrate branches, glabrous. *Leaves* linear, flattened, 5-15 x 1.3-2 mm, scattered along flowering branches but with one or two pairs clustered under the receptacle; basal leaves not seen. *Flowers* shortly pedicellate. *Perianth* free; segments triangular, equal, acute, 7.5-12.2 x 3-4.5 mm, outside surface green, smooth; inside surface white, papillose. *Stamens* numerous, in 2-3 whorls, evenly distributed around ovary; filaments terete, hirsute in lower part, minutely papillose in the upper parts; anthers smooth. *Ovary* shallowly ribbed towards apex; smooth, stigmas papillose. *Capsule* shallowly ribbed, slightly depressed at apex, 4-7 x 4-5.5 mm; valves acute, not splitting, expanding keels prominent along margins. *Seed* 0.7-0.8 x 0.6-0.7 mm, dark-brown, ovoid, laterally expanded into curved lobes, colliculate but in lateral parts cells elongated, cells arranged in rows. (Figs 7, 14, *45*; Map 4).

Although the type label of *G. divisa* gives only the vague locality "Murchison River" it seems likely that the species originated from the upper tributaries of this river. Indeed the only other collection known, which was also made by Isaac Tyson, was collected at Mt Narryer. Since a note in Tyson's handwriting accompanying this collection states that it was not numbered because he had sent some earlier this indicates that the exact type locality could be Mt Narryer.

In a note on one of the MEL isotypes Tyson stated that the species occurred on a conglomerate rise in "perfectly good soil" unlike a similar "flower" that he had sent earlier (described by Ewart as *Aizoon rodwayi*).

Other specimen examined:

WESTERN AUSTRALIA: *I. Tyson s.n.*, Mt Narryer, 1898 (K).

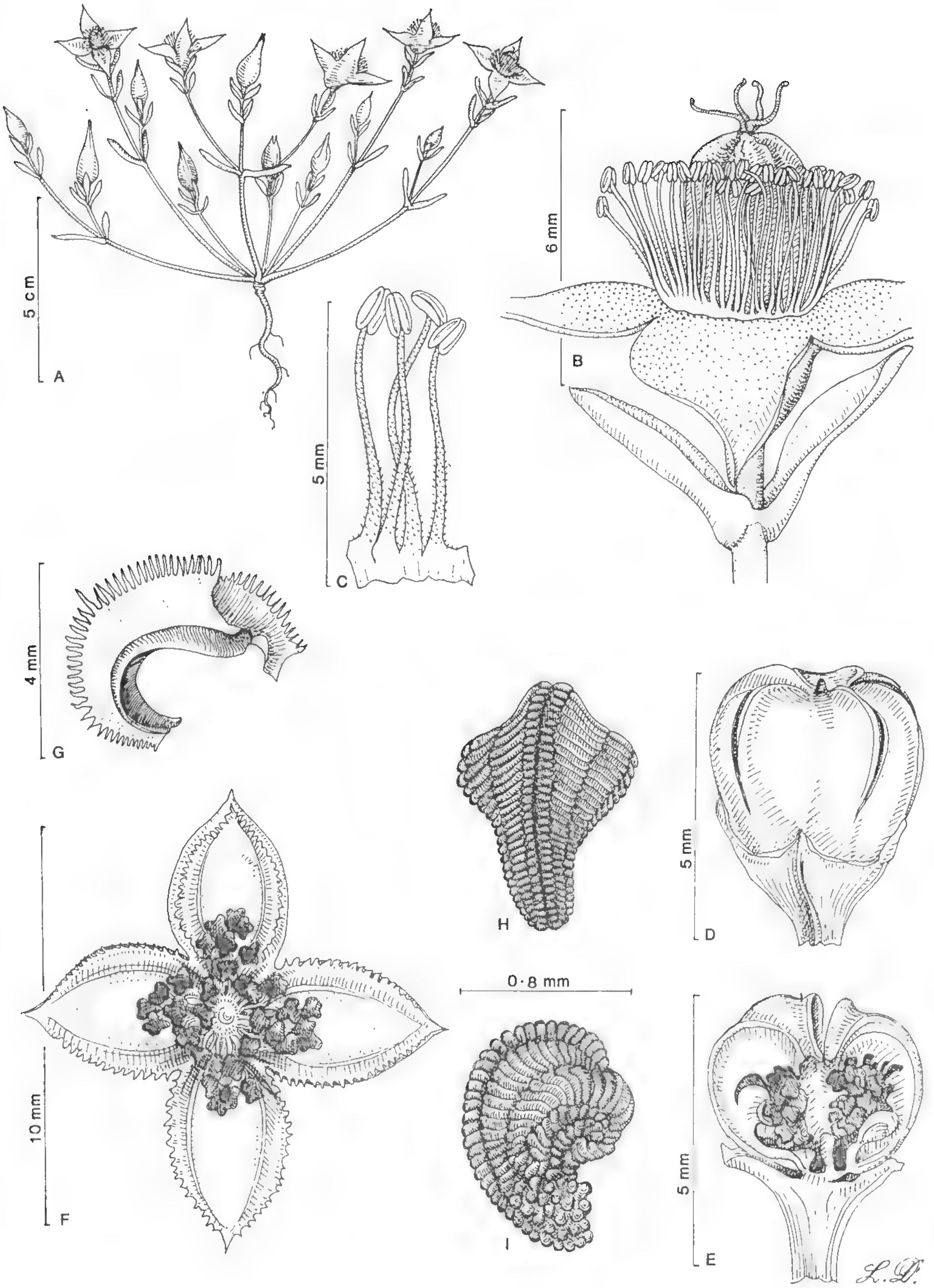


Fig. 45. *Gunniopsis divisa*. A, habit of plant; B, side view of flower; C, group of stamens; D, side view of capsule; E, longitudinal section through capsule; F, open capsule; G, lateral view of valve showing the prominently ciliate expanding keels; H-I, distal and lateral views of seed (based on *Tyson s.n.*, MEL 99600).

10. **Gunniopsis glabra** (Luehm. ex Ewart) Gardner, Enum. Pl. Aust. Occid. 2: 42 (1930); Blackall & Grieve, West. Aust. Wildfls 1: 163 (1954).

Type citation: "Murchison R., I. Tyson 1898; Mt Caroline 1891, Miss Sewell; Salt Lakes, Martha Heal".

Type: *Martha Heal s.n.*, Salt Lakes, no date (MEL 99596, lectotype here designated); syntypes: *Miss Sewell s.n.*, near Mt Caroline, 1891 (MEL 99598); *I. Tyson s.n.*, Murchison River, 1898 (MEL 99597, 99599, 99600).

Aizoon glabrum Luehm., ex Ewart, Proc. Roy. Soc. Vic. n.s. 20: 128 (1908); Beard, West. Aust. Pl. 31 (1975).

Typification

Ewart's circumscription of *Aizoon glabrum* was based on the three collections cited above but unfortunately they consist of two elements. The collections of Martha Heal and Miss Sewell are of a very distinct perennial species which stands apart from other species in the genus in having a fleshy taproot, very condensed branches clothed with persistent dilated leaf bases and inflorescences reduced to a solitary flower. Tyson's collections are of an herbaceous species similar to *G. rodwayi* in habit but differing in the perianth segments being divided to the base and seeds which in distal view are laterally expanded into lobes similar to that found in *G. kochii* (cf. *G. divisa*).

In lectotypifying *G. glabra* I have selected the taxon upon which fruit and seed characters appear to have been entirely based. Other vegetative and floral features have been drawn from both taxa and individual features of both species can be identified in the protologue.

Herb with usually a somewhat woody perennial base continued in a prominent taproot and with one to several rosettes above, glabrous. *Basal branches* condensed, solitary or branched, rarely more than 30 mm long, densely clothed in dilated, buff-coloured, papery, persistent leaf bases. *Flowering branches* 40-140 mm long, unbranched, wiry, glaucous grey-green tinged purple or blackish-purple, erect, spreading or prostrate. *Leaves* glaucous green to grey-green; basal ones subterete, flattened or slightly channelled on upper side, acute, dilated and sheath-like at base, 15-45 x 2-7 mm; leaves on flowering branches, lanceolate, more or less conduplicate, acute, 4.6-26 x 1.8-3 mm. *Flowers* solitary. *Perianth* fused basally; segments ovate to triangular, equal, acute, 7.5-12 x 4-6.3 mm, outside surface glaucous-green to grey-green, smooth; inside surface white, papillose. *Stamens* numerous, in up to 9 whorls, evenly distributed around ovary; filaments terete, hirsute in lower part, minutely papillose in upper part; anthers smooth. *Ovary* shallowly 4-ribbed, smooth; stigmas papillose. *Capsule* ovoid, obtuse, 4-7x 4-8 mm; valves when open deeply bifid and capsule appearing 8-valved when closed. *Seed* 1-1.5 x 0.7-0.8 mm, ovoid, in distal view with a prominently truncate apex, black, coarsely tuberculate. (Figs 17, 32, 33, 34, *46*; Map 4).

Widespread throughout the Avon and Coolgardie Botanical Districts of Western Australia where it occurs on sandy soils (rarely clay loam) on the margins of salt lakes.

Notes

Unlike the other species of *Gunniopsis*, which grow and flower from late winter to early summer, *G. glabra* has a distinctive vegetative phase and a delayed flowering period. Vegetative growth of the basal branches and leaves occurs during spring and at this stage the flowering stems elongate but the terminal solitary flowers do not develop. By November the basal leaves begin drying off and the flower buds start to enlarge. Flowering does not occur until late January or February and from cultivated plants it is suggested that the first opening of the flowers only occurs on extremely hot days.

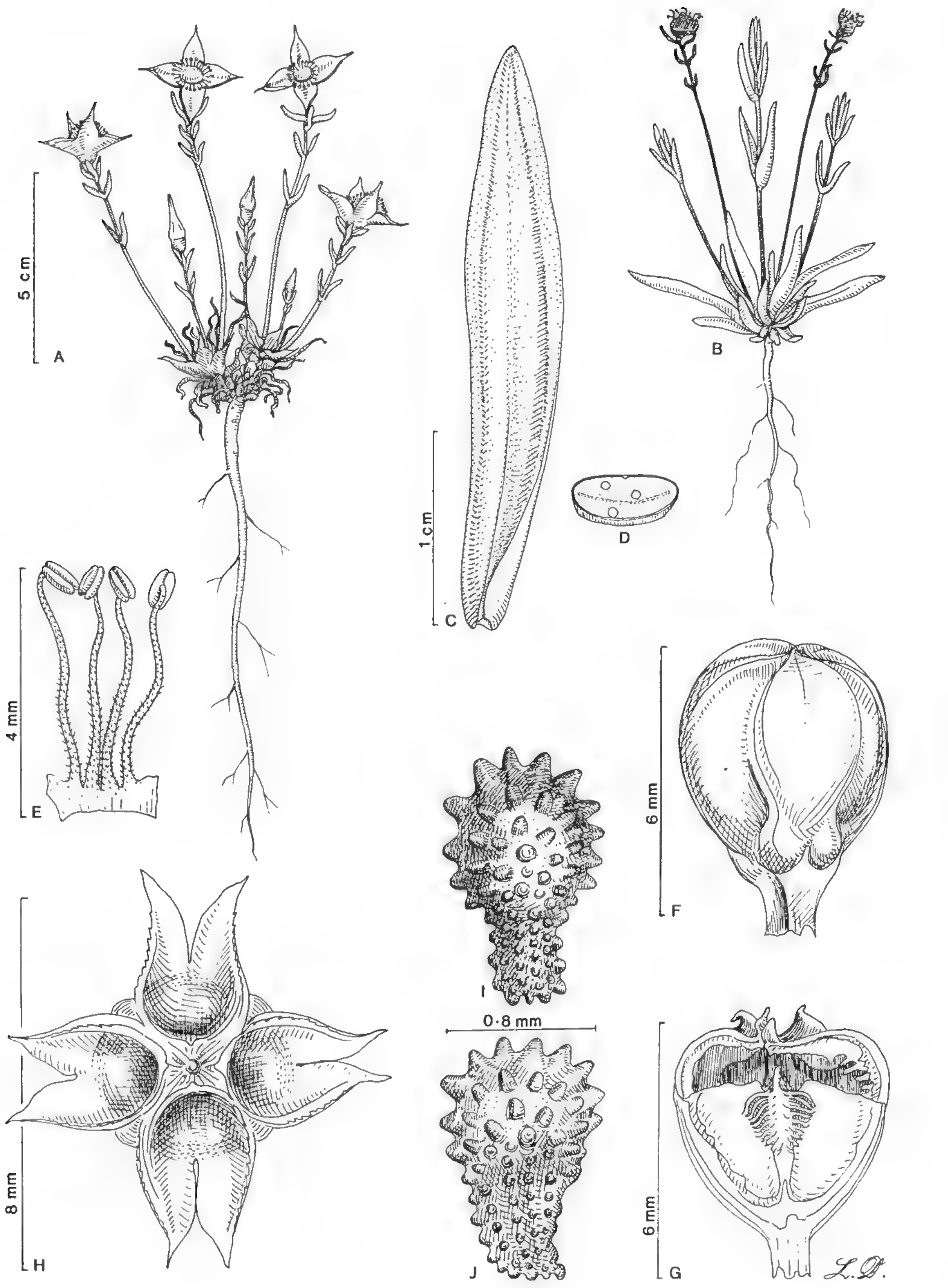


Fig. 46. *Gunniopsis glabra*. A, habit of flowering plant showing the dried up leaves; B, vegetative plant with the previous year's capsules and the young developing flowering branches; C, leaf; D, cross-section of leaf; E, group of stamens; F, lateral view of capsule; G, longitudinal section through capsule; H, open capsule; I-J, distal and lateral views of seed respectively (based on *Chinnock 5250*).

However, having once opened the flowers will continue to re-open each day for up to a fortnight or more irrespective of temperature.

One collection at PERTH (*W.H. Butler s.n.*) collected at Lake Barker Reserve is atypical of the species and may possibly be of hybrid origin or represent a new taxon. The basal portion of the plant consists of numerous densely clustered leaves (no root system is present) from which eighty flowering stems emerge. On most of these stems, lateral branches are suppressed but in the largest ones lateral shoots with flower buds are emerging from the leaf axils. It is possible that the plant may be a hybrid between *G. glabra* and *G. rodwayi*.

Specimens examined

WESTERN AUSTRALIA: *W.H. Butler s.n.*, Lake Barker Reserve, xi.1971 (PERTH); *R.J. Chinnock 4419 & P.G. Wilson*, Mortlock River just E of Meckering, 22.xi.1978 (AD); *R.J. Chinnock 5250*, western side of Lake De Courcy, 20.x.1981 (AD); *R.J. Chinnock 5254*, Salt Lakes 43.6 km E of Wubin, 20.x.1981 (AD); *R.J. Chinnock 5407*, southern side of Lake Brown, 4.xi.1981 (AD); *R.J. Chinnock 5408*, Salt Lake 39.4 km W of Bullfinch, 4.xi.1981 (AD); *R.J. Chinnock 5422*, Salt Lake, 28.9 km S of Bullfinch, 4.xi.1981 (AD); *R. Helms s.n.*, near Yilgarn, xi.1891 (AD 97617619); *R. Helms s.n.*, near Knutsford, 8.xii.1891 (AD 97617622); *E. Merrall s.n.*, Yilgarn goldfields near Lake Brown, 1888 (MEL 99650); *K. Newbey 5889*, southern end of Lake Seabrook, 11.ix.1979 (PERTH); *R.D. Royce 8411*, Mortlock River, Meckering, 8.ii.1968 (PERTH).

11. **Gunniopsis rodwayi** (Ewart) Gardner, Enum. Pl. Aust. Occid. 2: 42 (1930); Blackall & Grieve, West. Aust. Wildfls 1: 163 (1954).

Type: *F.A. Rodway s.n.*, dried up Salt Lake, Desdemona, Western Australia, 1907 (MEL 99633, lectotype designated here); syntype; *Isaac Tyson s.n.*, Nannine Salt Marsh, 1893 (MEL 99634).

Aizoon rodwayi Ewart, Proc. Roy. Soc. Vic. n.s. 30: 129 (1908).

Herb 2-16 x 2-50 cm, erect or prostrate, glabrous. *Branches* at first glaucous grey-green, smooth or with scattered protruding salt pustules, on drying turning stramineous, striate. *Leaves* glaucous, grey-green, basal ones oblong, flat or slightly channelled, obtuse; leaves on flowering branches ovate to lanceolate, obtuse or acute, in side view ± falcate, conduplicate, connate base clasping branch, 5.5-40 mm long. *Flowers* pedicellate. *Perianth* fused basally; segments ovate to triangular, two longer, with terete acuminate apices, 5-20 x 2.5-12 mm; outside surface glaucous grey-green, smooth or with protruding salt pustules; inside surface white, although sometimes the margins turning pinkish, papillose. *Stamens* numerous, in 2 (?3) whorls, grouped in four bundles alternate with segments or almost forming a continuous ring around ovary; filaments terete, hirsute in lower part, minutely papillose in upper part; anthers smooth. *Ovary* shallowly 4-ribbed in upper part, smooth; stigmas smooth. *Capsule* 4-ribbed, 5-5.5 x 4.5-6 mm; valves when opened deeply bifid and often appearing 8-valved. *Seed* c. 1.2 x 0.7-0.8 mm, ovoid, in distal view with prominently truncate apex, black, tuberculate. (Figs 19, *47*; Map 4).

Widespread throughout the Austin, Ashburton and Avon Botanical Districts of Western Australia. Commonly found in sand around the margins of salt lakes, usually on the upper edges of *Halosarcia* low shrublands. It frequently occurs with *G. quadrifida*.

Notes

The habit of this species varies considerably depending on the availability of moisture during the growing period. With good rains or in positions such as on damp sand adjacent to pools, growth is very rapid with much branching resulting in large plants to 50 cm in diameter. Often, however, sufficient rains only fall to initiate germination and then they are not followed up by more to maintain growth so that depauperate plants result which have only one erect and a few prostrate branches which are usually little branched.

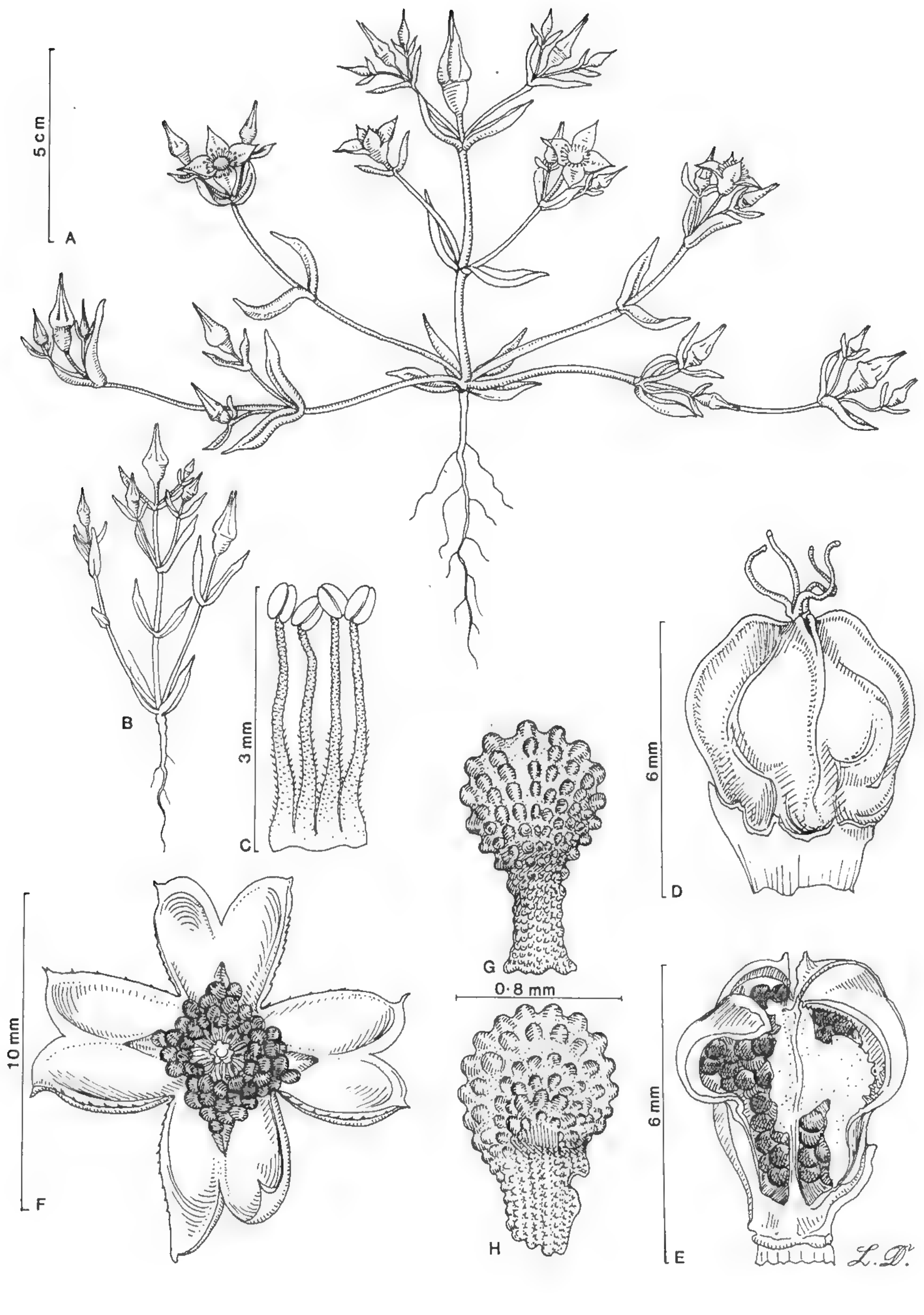


Fig. 47. *Gunniopsis rodwayi*. A, habit of medium sized plant with erect and prostrate branches; B, small plant with erect branches; C, group of stamens; D, lateral view of capsule; E, longitudinal section through capsule; F, open capsule; G-H, distal and lateral views of seed (based on *Chinnock 5169*).

Specimens examined

WESTERN AUSTRALIA: *B.G. Briggs s.n.*, 3 miles SE of Morawa, 1.x.1960 (NSW 147628); *R.J. Chinnock 763*, Beru Pool, Yelma Station, 5.ix.1973 (AD, PERTH); *R.J. Chinnock 4694*, 3.8 km E of Carnegie, 16.ix.1979 (AD); *R.J. Chinnock 5169*, Lake Annean, 5.8 km W of Nannine, 16.x.1981 (AD); *R.J. Chinnock 5186*, northern edge of Lake Austin 18.2 km S of Cue, 17.x.1981 (AD); *R.J. Chinnock 5225*, 13.9 km S of Metters Bore, Paynes Find—Cleary Road, 19.x.1981 (AD); *R.J. Chinnock 5270*, 7 km S of Morawa, 21.x.1981 (AD); *E. Clark 280*, E of Laverton, 1916 (PERTH); *C.A. Gardner 7810A*, Lake View Station, 20 m W of Cue, 12.x.1945 (PERTH); *C.A. Gardner 7847A*, Lake Annean, Nannine, 13.x.1945 (PERTH); *C.A. Gardner 12037*, near Lake Monger, 10.xii.1958 (PERTH); *N.H. Speck 1430*, 18 miles W of Yelma, 11.ix.1958 (AD, CANB, PERTH); *H.R. Toelken 6102*, 32 km E of Wiluna, 12.ix.1979 (AD); *P.G. Wilson 7290*, Lake Carey, northern margin c. 225 km NNE of Kalgoorlie, 26.viii.1968 (PERTH); *P.G. Wilson 11594*, Lake Austin, c. 18 km S of Cue, 14.ix.1973 (PERTH).

12. **Gunniopsis septifraga** (F. Muell.) Chinnock, comb. nov.

Gunnia septifraga F. Muell., Rep. Babb. Exped. 9 (1859); Benth., Fl. Aust. 3: 327 (1867); Pax in Engl. & Prantl. Nat. Pflanzenfam. 1st edn 3, 1: 43 (1894); Bailey, Qd Fl. 2: 707 (1900).

Type citation: "Stuart's Creek".

Type: *Hergolt s.n.*, Stuarts Creek, South Australia, 1858 (holotype: MEL 589314).

Gunnia drummondii Benth., Fl. Aust. 3: 327 (1867); Tate, Fl. Extratrop. S. Aust. 87 (1890); Black, Fl. S. Aust. edn 1: 221 (1924); Gardner, Enum. Pl. Aust. Occid. 2: 42 (1930); Blackall & Grieve, West. Aust. Wildfls 1: 163 (1954).

Type: *Drummond 241*, Swan River, no date (holotype: K).

Neogunnia drummondii (Benth.) Pax & Hoffm., in Engl. & Prantl, Nat. Pflanzenfam. 2nd edn 16c: 225 (1934).

Neogunnia septifraga (F. Muell.) Pax & Hoffm., in Engl. & Prantl, Nat. Pflanzenfam. 2nd edn 16c: 225 (1934); Black, Fl. S. Aust. edn 2: 340 (1963); Toelken in Jessop, Fl. Cent. Aust. 36 (1981); Jacobs & Pickard, Cens. Pl. N.S.W. 62 (1981).

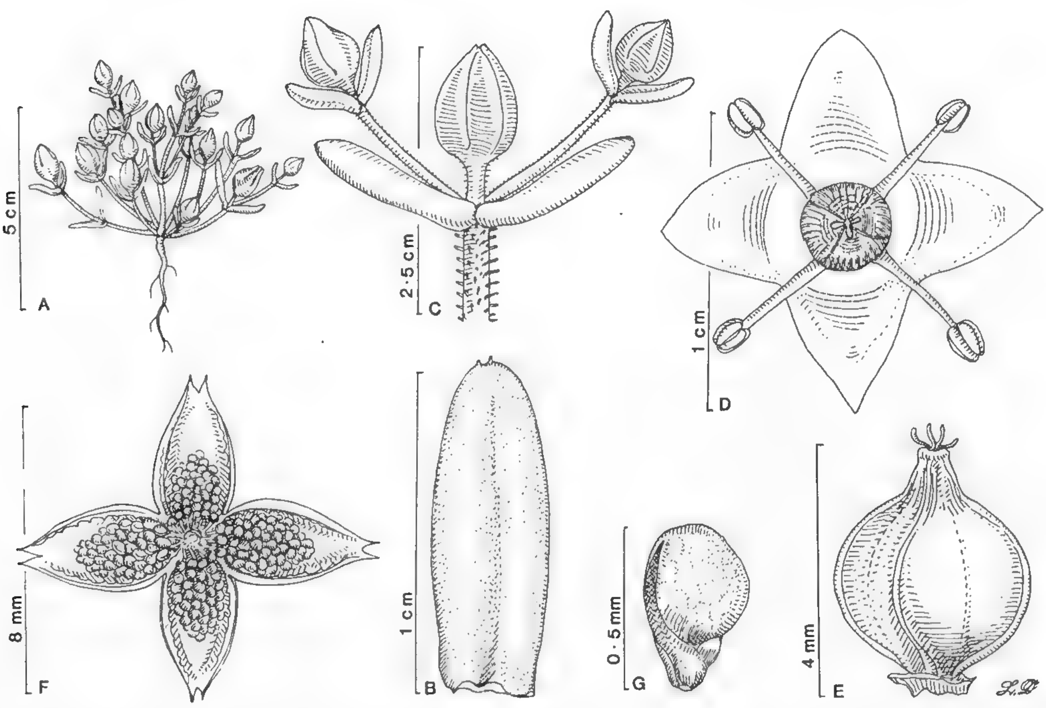
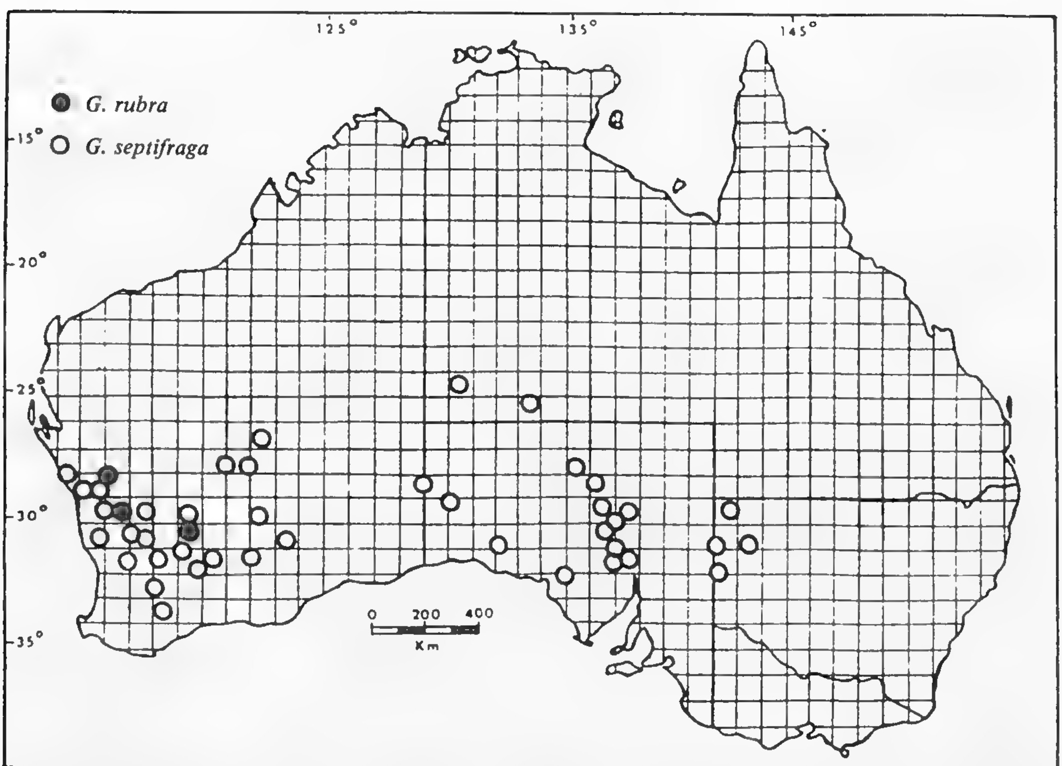


Fig. 48. *Gunniopsis septifraga*. A, habit of plant; B, leaf; C, habit of branch with flower buds and prominent succulent hairs; D, open flower; E, lateral view of capsule; F, open capsule; G, lateral view of seed (based on *Chinnock 5286*).

Herb 0.5-5 x 2-15 (-25) cm, prostrate, caespitose. *Branches* green to yellow, smooth, stramineous and striate when dry, glabrous or sparsely pubescent, hairs clavate. *Leaves* green turning yellow-green to stramineous as plant matures and dries off, oblong to oblanceolate, obtuse, 5-15 x 1.0-4.8 mm, glabrous. *Flowers* sessile or shortly pedicellate. *Perianth* fused basally; segments triangular, equal, acute, 2.4-6 x 2-6.2 mm; outside surface green to yellow, smooth; inside surface green, smooth to obscurely papillose. *Stamens* 4, rarely 8, in a single whorl, alternate with perianth segments; filaments terete but slightly flattened near base; anthers glabrous. *Ovary* 4-ribbed, smooth; stigmas papillose. *Capsule* 4-ribbed, tapering to a beak-like apex, 2.5-4.5 x 2.3-3.7 mm; valves emarginate to deeply bifid, and if latter, capsule when closed appearing 8-valved. *Seed* 0.5-0.7 x 0.3-0.5 mm, ovoid, whitish to hyaline but normally brown along distal side, obscurely rugose, or smooth except for rugose distal side. (Figs 10, 23, 24, 35, *48*; Map 5).

Extremely widespread throughout the saline lake systems of Western and South Australia and extending into the southern Northern Territory and western New South Wales.

G. septifraga occurs in extremely saline situations and grows along the edges of, or on the damp bottoms of, salt lakes, salt pans or depressions. On lake margins this species often forms dense patches on open flats or around the bases of *Halosarcia* shrubs.



Map 5. Distribution of *G. rubra* and *G. septifraga.*

Selected specimens (collections seen: 57)

WESTERN AUSTRALIA: *J.S. Beard 2090*, Binnu, 28.ix.1962 (PERTH); *R.J. Chinnock 820*, 14.5 km SE of Windidda Homestead, 6.ix.1973 (AD, PERTH); *R.J. Chinnock 5383*, 14.5 km S of Pingrup, 2.xi.1981 (AD); *C.A. Gardner s.n.*, Mortlock River Flats, Meckering, 22.x.1945 (PERTH); *D.E. Symon 12640A*, Tjidilchurra Rockhole, 26.viii.1980 (ADW).

NORTHERN TERRITORY: *T.S. Henshall 2114*, Palmer Valley Station, 6 km NNE of Kingston No. 2 Dam, 6.ix.1978 (AD, NT); *J.R. Maconochie 1895*, Lake Neale, 28.viii.1973 (AD, MEL, NSW, PERTH); *J.R. Maconochie 2536*, Karinga Creek, 15.ix.1978 (AD); *R.W. Swartz*, Finke River, 1889 (MEL 99703, 99706).

SOUTH AUSTRALIA: *R.J. Chinnock 2727*, Ifould Lake, 2.x.1978 (AD); *B. Copley 2209*, 3 km from Coward Springs, 3.ix.1968 (AD); *E.H. Ising s.n.*, 12 miles S of Oodnadatta, 30.viii.1955 (AD 97651095, ADW); *T.R.N. Lothian 4044*, 55 km NE of Wirrula, 4.vi.1967 (AD); *D.E. Symon 2738*, 24 miles S of Woomera, 14.viii.1962 (ADW).

NEW SOUTH WALES: *G.M. Cunningham & P.L. Milthorpe 1172*, Nuntherungie, c. 40 km E of Lake Bancannia, 19.ix.1973 (NSW); *Mrs Irvine s.n.*, near Silverton, 1889 (MEL 99709); *Mrs Irvine s.n.*, Barrier Ranges, ix.1889 (MEL 997080); *S. Jacobs 4146*, 10 km W of Tibooburra, 8.ix.1981 (NSW).

13. **Gunniopsis rubra** Chinnock, sp. nov.

Planta herbacea parva prostrata glaber ramis foliis et floribus viridibus rubescentibus; foliis oblongis subteretibus; *perianthii segmentis* basibus divisis interne viridis; *staminibus* 4; *capsula* ovoidea obtusa; valvis 4 acutis; *seminibus* ovoideis brunneis dilutis laevibus nitidis.

Type: *R.J. Chinnock 5268*, 20 km SE of Perenjori, 21.x.1981 (holotype: AD; isotype: K, MEL, PERTH, NT, US).

Etymology: Latin *ruber*; red; referring to the colour the plant turns as it matures.

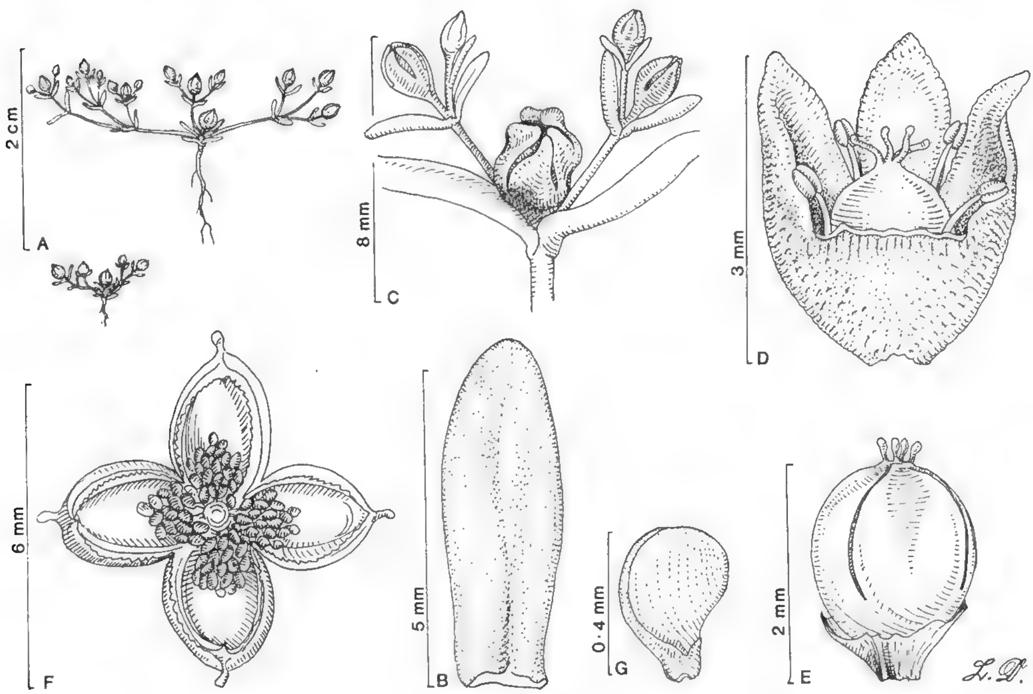


Fig. 49. *Gunniopsis rubra*. A, habit of large and small plant; B, leaf; C, enlargement of branch with flowers; D, open flower; E, lateral view of capsule; F, open capsule with persistent stigmas on tips of valves; G, lateral view of seed (based on *Chinnock 5268*).

Herb c. 1 x 2-12 cm, prostrate, glabrous. *Branches* green to red, smooth when fresh but striate when dry. *Leaves* green to red, oblong, subterete, flattened above, 3.5-10 x 0.7-1 mm. *Flowers* sessile or pedicellate. *Perianth* free; segments triangular, equal, apex terete and margins with large scattered papillae but not obvious in dried material, 2.5-4.5 x 1.3-2.1 mm; outside surface green to red, ± rugose; inside surface green, smooth. *Stamens* 4, in a single whorl, alternate with the segments; filaments terete, glabrous; anthers smooth. *Ovary* globular, smooth; stigmas smooth. *Capsule* ovoid, with apex obtuse, membranous, 2-2.6 x 1.5-2.5 mm; valves 4, acute, not bifid at apex. *Seed* 0.4 x 0.25-0.3 mm, ovoid, light brown, shiny, smooth except for furrows along the distal face. (Fig 9, *49*; Map 5).

Restricted to Western Australia where it is known from three localities in the northern part of the Avon and the western part of the Coolgardie Botanical Districts. Probably more widespread but overlooked because of its small size.

Unlike *Gunniopsis septifraga*, which grows in extremely saline situations, *G. rubra* is known only to grow on light brown sandy loams and red loams under open *Eucalyptus* woodlands. At the type locality the species formed extensive patches in open areas between the mallee plants. It also occurred with *Calandrinia* and *Borya* on exposed granite, and on the margins of a wheat field.

Specimens examined

WESTERN AUSTRALIA: *G.J. Keighery 3318*, 60 km E of Mullewa, 29.viii.1980 (AD, KP); *K. Newbey 9328*, 5.3 km NNE of Yacke Yackine Dam, c. 75 km NNW of Bullfinch, 3.x.1981 (PERTH).

14. **Gunniopsis propinqua** Chinnock, sp. nov.

Planta herbacea parva glabra; *foliis* linearibus; *perianthii segmentis* connatis, ovatis vel triangularibus, interne albis vel roseis; *staminibus* 4-12, fasciculis et 4 segmentis alternatibus; *capsula* ovoideo obtuso valvis profunde bifidis; *seminibus* ovoideis, aspectu distalibus triangularibus, colliculosis, cellularis 5-7 serialibus.

Type: *P.G. Wilson 7436*, von Truer Tableland, S of Lake Carnegie, Western Australia, 28.viii.1968 (holotype: PERTH; isotype: K).

Etymology: Latin *propinquus*, near: alluding to the similarity of this species to *G. septifraga*.

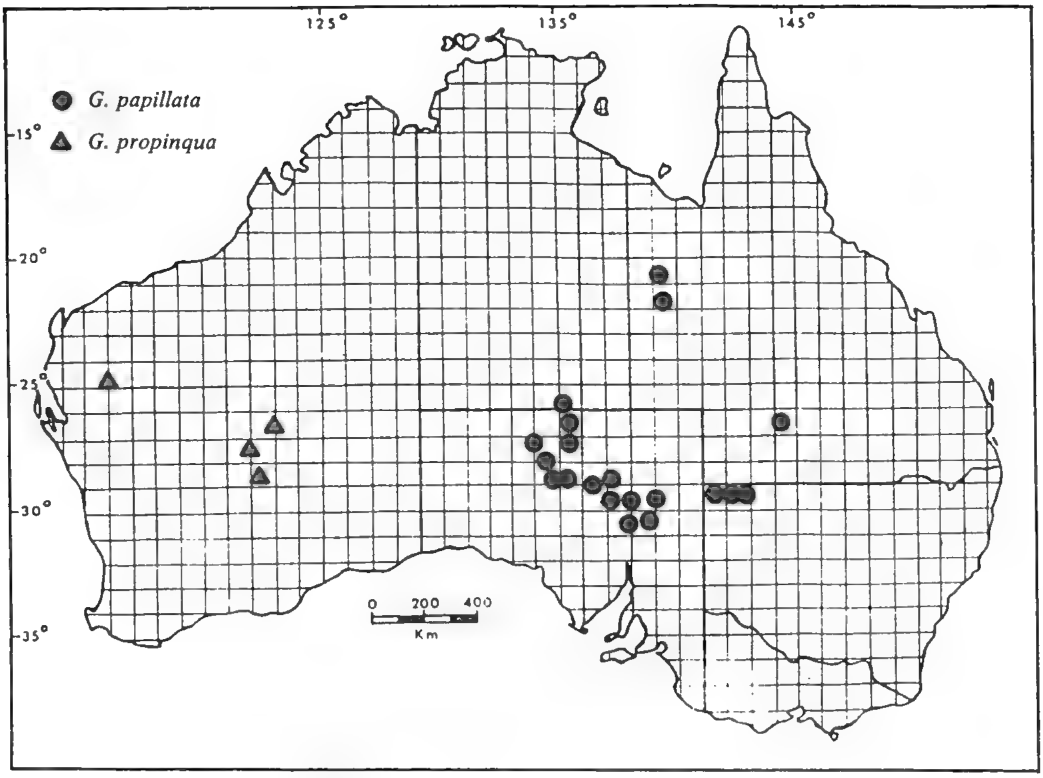
Herb 3-10 x 9-12 cm, prostrate, glabrous. *Branches* green turning stramineous when dry, smooth but often with scattered protruding salt pustules. *Leaves* green, linear, slightly channelled above, 8-12 (-24) x 1-2 mm, papillose, often with protruding salt pustules at least when dry. *Flowers* shortly pedicellate. *Perianth* fused basally; segments ovate to triangular, acuminate, 5-9.5 x 2.3-5 mm; outside surface green, inside surface white or pink. *Stamens* 4-12, in a single whorl, arranged in four bundles alternate with perianth segments, number in each bundle 1-3 and often unequal in same flower; filaments slightly flattened and dilating gradually towards base; anthers smooth. *Ovary* ovoid, shallowly 4-ribbed, smooth; stigmas smooth. *Capsule* ovoid, obtuse, ribbed to non-ribbed, 3 x 3-3.6 mm, membranous; valves when open deeply bifid. *Seeds* 0.4-0.7 x 0.35-0.5 mm, ovoid but ± triangular in distal view, light to dark-brown, colliculate with cells arranged in 5-7 rows (distal view). (Figs 35, *50*; Map 6).

G. propinqua is restricted to Western Australia and is known from a number of localities in the eastern part of the Austin Botanical District, and one locality in the extreme north-west of the Ashburton District.

This species grows in less saline situations than *G. septifraga* favouring lateritic outcrops or sandy stony loams.

Specimens examined

WESTERN AUSTRALIA: *W.E. Blackall 421*, near Laverton, E of Menzies, 10.viii.1931 (PERTH); *R.J. Chinnock 741*, 16 km S of 10 mile tank on Bandya-Banjiwarn road, 3.ix.1973 (AD); *P.G. Wilson 7285*, Mt Margaret, c. 32 km SW of Laverton, 26.viii.1968 (PERTH); *E. Wittwer 1041*, Mt James Station, 17.viii.1973 (PERTH).



Map 6. Distribution of *G. papillata* and *G. propinqua*.

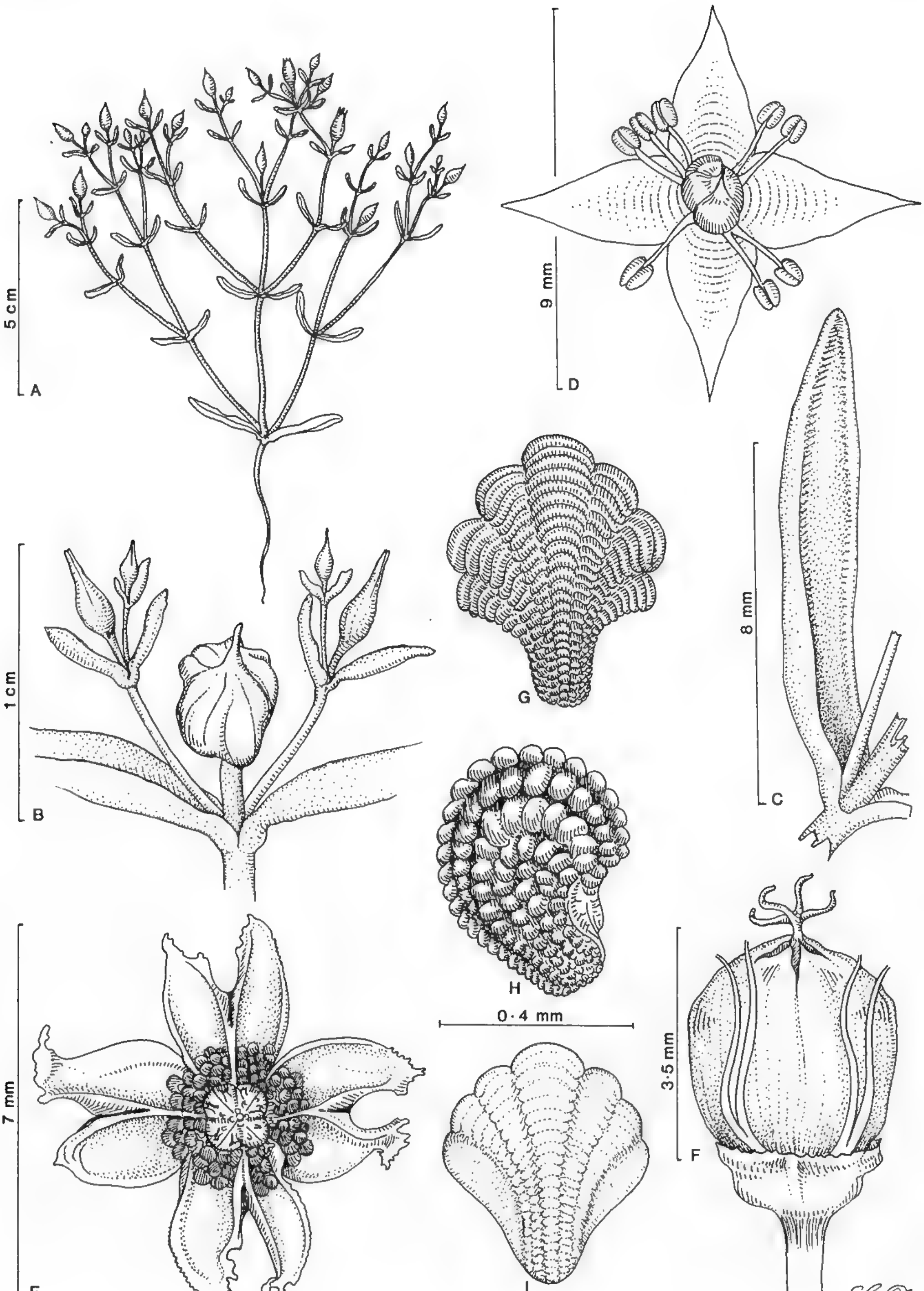


Fig. 50. *Gunniopsis propinqua*. A, habit of plant; B, enlargement of branch with leaves and buds; C, leaf; D, open flower showing variation in stamen number (based on a number of flowers); E, open capsule; F, view of capsule and persistent filaments; G, I, distal views of seeds; H, lateral view of seed (A-C, E-H, *Wilson 7436*; D, F, *Chinnock 741*).

Acknowledgements

I thank Mr Graham Bell for assisting me in the field and for scanning pollen and seed material; Dr John Jessop for checking my Latin descriptions; Dr Jackie Venning for discussions relating to *Gunniopsis*; Dr Wayne Harris for examining pollen, Mr Ludwik Dutkiewicz for illustrating the species and Miss Barbara Welling for typing the manuscript.

The Directors/Curators of the following herbaria are thanked for the loan of herbarium material: ADW, BRI, CANB, K, MEL, NSW, NT, PERTH and PRE.

This work was partially funded by the Australian Biological Resources Study.

References

Adamson, R.S. (1959). The South African species of Aizoaceae. 7. Aizoon. *J.S. Afr. Bot.* 25: 29-50.

Beard, J.S. (1965). "A descriptive Catalogue of West Australian Plants". (Society for Growing Australian Plants: Sydney).

Beard, J.S. (1980). A new phytogeographic map of Western Australia. *West. Aust. Herb. Research Notes* 3: 37-58.

Bentham, G. (1867). "Flora Australiense". Vol. 3. (Reeve: London).

Black, J.M. (1924). "Flora of South Australia". 1st edn. Vol. 2. (Govt Printer: Adelaide).

Black, J.M. (1948). "Flora of South Australia". 2nd edn. Vol. 2. (Govt Printer: Adelaide).

Blackall, W.E. & Grieve, B.J. (1954). "How to know Western Australian Wildflowers". Part 1. (University of Western Australian Press: Nedlands).

Burbidge, N.T. (1960). The phytogeography of the Australian Region. *Aust. J. Bot.* 8: 75-212.

Diels, L. in Diels, L. & Pritzel, E. (1904). Fragmenta phytographae Australiae occidentalis. *Bot. Jahrb. Syst.* 35: 196-197.

Dyer, R.A. (1975). "The Genera of Southern African Flowering Plants". Vol. 1. (Govt Printer: Pretoria).

Erdtman, G. (1952). "Pollen Morphology and Plant Taxonomy". (Almqvist & Wiksell: Stockholm).

Ewart, A.J. (1908). Contributions to the flora of Australia 7. *Proc. Roy. Soc. Vic.* n.s. 20, 2: 128-129.

Friedrich, H.Ch. (1970). Aizoaceae. In Merxmüller H. (Ed.). "Prodromus einer Flora von Südwestafrika". (Cramer: Lehre).

Gardner, C.A. (1930). "Enumeratio plantarum Australiae occidentalis". (Govt. Printer: Perth).

Green, J.W. (1981). "Census of the Vascular Plants of Western Australia". (Western Australian Herbarium: South Perth).

Jacobs, S.W.L. & Pickard, J. (1981). "Plants of New South Wales". (Govt Printer: Sydney).

Linnaeus, C. (1753). "Species Plantarum". (Stockholm).

Maiden, J.H. & Betche, E. (1916). "A Census of New South Wales Plants". (Govt Printer: Sydney).

Mueller, F. (1859). "Report on the Plants collected during Mr Babbage's Expedition into the North West Interior of South Australia in 1858". (Govt Printer: Melbourne).

Mueller, F. (1861). "Fragmenta Phytographiae Australiae". 2: 148-149. (Govt Printer: Melbourne).

Mueller, F. (1871). "Fragmenta Phytographiae Australiae". 7: 129. (Govt Printer: Melbourne).

Pax, F. (1895). "Aizoaceae". In Engler, A. & Prantl, K. (Ed.). "Die natürlichen Pflanzenfamilien". 1st edn 3, 1b: 33-51 (Engelmann: Leipzig).

Pax, F. & Hoffman, K. (1934). "Aizoaceae". In Engler, A. & Prantl, K. (Ed.). "Die natürlichen Pflanzenfamilien". 2nd edn 16c: 179-233. (Engelmann: Leipzig).

Stearn, W.T. (1973). "Botanical Latin". 2nd edn. (David & Charles: Newton Abbot).

Toelken, H. (1981). "Aizoaceae". In Jessop, J. (Ed.). "Flora of Central Australia". 35-39. (Reed: Sydney).

Troll, W. & Weberling, F. (1981). Infloreszenzstudien on Aizoaceen, Mesembryanthemaceen und Tetragoniaceen. (Steiner: Wiesbaden).

Wagner, R. (1904). Ein neues Aizoon aus Südaustralien. *Ann. Naturhist. Hofmus.* 29: 79-84.

Index to Scientific Names

Names

New names and combinations are in **bold**. Synonyms, misapplied or illegitimate names are in *italic*.

Page numbers

Page numbers in **bold** refer to the main taxonomic treatment and an asterisked refers to figures and maps.

J. Adelaide Bot. Gard. 6(2): 181-188 (1983)

THREE NEW SPECIES OF *TETRAGONIA* AND *TRIANTHEMA* (AIZOACEAE)

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Abstract

Three new species of the family Aizoaceae are described and illustrated. *Tetragonia cristata* C.A. Gardner ex Prescott is from Western Australia, *Trianthema megasperma* Prescott, from the Northern Territory and *Trianthema patellitecta* Prescott, from the north-western part of Australia. The affinities of these taxa are discussed, distribution maps and ecological data are provided.

Introduction

Little work has been done on the family Aizoaceae in Australia since Bentham's treatment in 1870, and only few native species are known from the comparatively poorly collected interior of the continent. Of about 40 species recorded for Australia, as compared with an estimated 1200 species in the world, about half are introduced and have become weeds. Almost all the Australian species of *Trianthema* and *Tetragonia* were described by F. Mueller (1859, 1876, 1884, 1895). An additional species, *Tetragonia eremaea* was described by Ostenfeld (1921) and *Trianthema compacta* by C.T. White (1919). The family has now been examined as part of a flora treatment for the "Flora of Australia" and three new species of *Trianthema* and *Tetragonia* are here described in preparation for this publication. New species of *Gunniopsis* are described elsewhere by R.J. Chinnock.

This paper brings the accepted number of species in Australia to 12 for *Trianthema* and eight in *Tetragonia.*

Tetragonia cristata C.A. Gardner ex Prescott, sp. nov.

Affinis *T. tetragonoidi* (Pallas) Kuntze et *T. eremaeae* Ostenf. sed fructu turbinato base cuneato et alis quatuor extensis supra fructu, cristarum convolutarum numero inter alas et pagina dense papillosa differt.

Type: Between Gidgee and Youno Downs, W.A., *C.A. Gardner 24467*, 22 Aug., 1963, (PERTH, holo).

The specific epithet was pencilled on one of Gardner's collections in his own hand (*C.A. Gardner 24467*) but the name was never published. It seems that the name refers to the convoluted ridges along the fruit.

Description

Prostrate annual herb with stems to 60 cm long, succulent, glabrous or with a few vesicular hairs on young growth, crystalline on all parts. *Leaves* alternate, scattered, constricted into petiole 5-20 mm long; lamina flat, ovate to rhomboid, 5-50 mm long, 3-25 mm broad, apex usually acute, mid-vein visible below, densely papillose. *Flowers* solitary at each node, sessile, axillary. *Perianth*: lobes 4, lanceolate to ovate, papillose outside, glabrous inside, c. 3 mm long, yellow. *Stamens* 12-30, c. 2 mm long. *Ovary* top-shaped, densely papillose, c. 2 mm long; styles 4-8, c. 3 mm long, terete; stigmatic surface on one edge, recurved; ovules 4-8. *Fruit* top-shaped, with four wings extending above fruit, cuneate at base, with a number of convoluted ridges between wings, densely

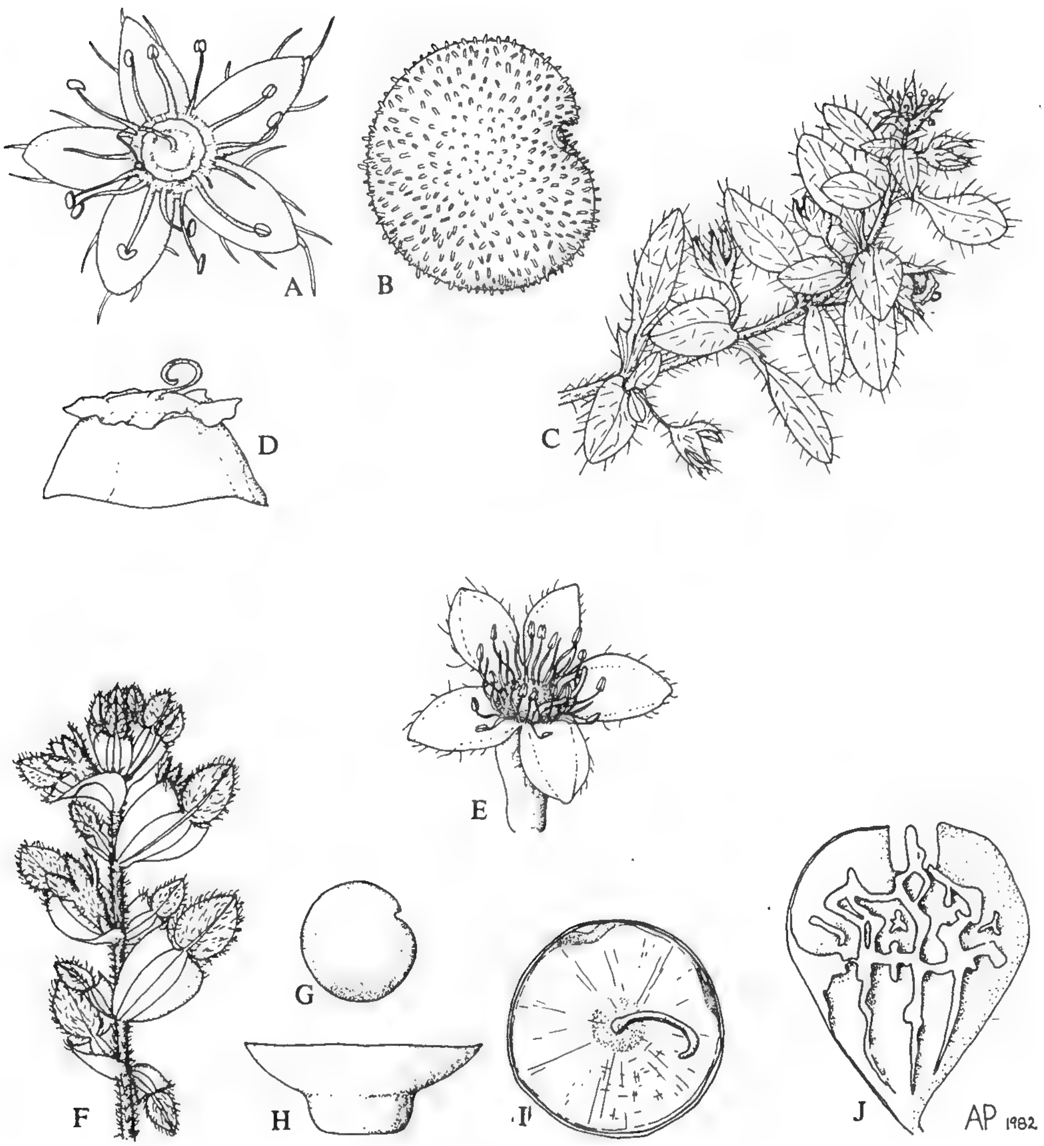

Fig. 1. A-D, *Trianthema megasperma*: A, flower from above, x4 (*Lazarides 7990*); B, seed covered with papillae, x10; C, habit showing solitary pedicellate flowers, x2; D, operculum with undulating rim near the top, x10; (B-D, *Gittins 2893*); E-I, *Trianthema patellitecta*: E, flower, x4 (*Bedbrook 4E*); F, habit, x2; G, seed x10; H, operculum in side view, x10; I, operculum from above showing hyaline cover, x10 (F-I, *Bennett 1734*); J, *Tetragonia cristata*: fruit showing surface structure but papillae not shown, x3 (*Demarz 6943*).

papillose, drying bony or woody, 8-15 mm long, 8-12 mm broad at widest point, purplish when fresh. *Seeds* several, each with separate woody casing, c. 3 mm long, pear-shaped, smooth, pale brown. (Fig. 1 & 2).

Distribution

Western Australia. Most of the specimens were collected in the vicinity of Meekatharra. (Map 1).

Specimens examined

WESTERN AUSTRALIA: Yagahong Hill, 50 km south-south-east of Meekatharra on the Sandstone Road, 27° 04′ S, 118° 40′ E, Ashburton District, *R.J. Chinnock 1031*, 14.ix.1973, fruit (AD); 30 miles N of Meekatharra, *C.A. Gardner 2330*, 17.vii.1931, flower and fruit (PERTH); Woodleigh Station, W.A.; *R. O'Farrell 42*, Sept. 1967, fruit (PERTH); 1 km S of Lake Austin, W.A.: *H. Demarz 6943*, 11.x.1978, fruit (PERTH); 200 km N of Northampton on Carnarvon Road, W.A., *W.E. Blackall 4552*, 31.viii.1940, flower and fruit (PERTH, 2 sheets); Belele Station WNW of Meekatharra, Chaddlebubba paddock, W.A., *D.W. Goodall 3068*, 8.xi.1965, flower and fruit (PERTH); Wadatharra Creek, 12 m W of Mt Magnet, W.A., *C.A. Gardner s.n.*, 11.x.1945, fruit (PERTH); Upper Murchison River, W.A., *Isaac Tyson s.n.*, 1892, flower and fruit (MEL 99868); 8 miles W of Mileura on Nookawarra Road, Eremean Province, W.A., *N.H. Speck 1010*, 19.vii.1958, fruit (AD); 143 miles N of Mullewa, S-W Division, W.A., *A.M. Ashby 4763*, 1.vii.1973, flower (AD 97421120); 19 miles W of Byro, W.A., *D. Demarz D3316*, 13.viii.1971, flower and fruit (PERTH).

Affinities

Vegetatively the species is indistinguishable from both *Tetragonia tetragonioides* (Pallas) Kuntze and *Tetragonia eremaea* Ostenf., and the three are extremely variable in the shape and size of the leaves. It is distinguished by the shape of the fruit as well as a number of convoluted ridges between the wings and its densely papillose surface. *T. tetragonioides* is largely restricted to the eastern half of Australia and *T. eremaea* to southern Australia, while *T. cristata* has mainly been recorded from central Western Australia.

Ecology

The habitat notes from the herbarium sheets vary greatly and include the following range:- 'Growing on rocky areas above cliffs', 'Granite outcrops', 'Red clay flat', 'Clay-calcareous' and 'Red sand'.

Trianthema megasperma Prescott, sp. nov.

Similis *T. pilosae* F. Muell. sed operculo campanulato pariete tenue et crista undulata prope apicum, semine uno duplo amplitudine (c. 3 mm lato) et floribus majoribus, solitariis et pedicelatis differt.

Type: c. 17 miles N of Mt Evelyn, 132° 45′ E, 13° 31′ S, 3.iii.1973, *M. Lazarides 7990* (holotype: CANB 265836; isotypes: BRI 224764; NT 52613).

The specific epithet refers to the single seed which is twice as large as the seeds of most other species in the genus.

Description

Prostrate perennial herb with stems to 1 m long, densely hirsute with long spreading hairs on all parts, hairs 2.0-3.0 mm long. *Branchlets* regularly alternate. *Leaves* opposite, one of each pair distinctly larger than the other; petiole c. 6 mm long, or on larger leaves dilated into membranous sheath immediately below lamina; lamina flat, ovate to obovate or spathulate, 3-30 mm long, 3-15 mm broad, acute or obtuse, with mid-vein depressed above, distinctly raised below, pale-green, strongly discolourous. *Flowers* solitary at each node, pedicellate; pedicel 2-10 mm long. *Perianth*: lobes 5,

Fig. 3. Holotype of the name *Trianthema megasperma*, *Lazarides 7990* (CANB).

Fig. 2. Holotype of the name *Tetragonia cristata*, *Gardner 24467* (PERTH).

narrow-triangular to ovate, with scarious margins and distinct dorsal appendage just below the apex, spreading, hirsute outside, glabrous inside, white to pink with mauve tips, c. 6 mm long; perianth tube very short. *Stamens* 5-15, 2.5-4 mm long; filaments terete. *Ovary* ovoid, with distinct terminal rim, 3 mm diameter; style 2.5 mm long, recurved at the blunt tip; ovules 2. *Fruit* a dry ovoid capsule, dehiscing by circumscissal split near base; operculum campanulate, thin-walled, with undulating ridge near top, 3 mm broad, tightly enclosing the large seed. *Seed*, one maturing per capsule, c. 3 mm broad, dorsiventrally compressed pea-shaped, black, reticulate or rugose, studded with small clear papillae, lifting the operculum when mature. (Figs 1 & 3).

Distribution

Northern Territory. Restricted to an area close to the north-western edge of Arnhem Land. (Map 2).

Specimens examined

NORTHERN TERRITORY: 8 miles N Mudginberry Homestead, *N. Byrnes NB 807*, 18.v.1968, flower and fruit (BRI, DNA, NSW, NT); Koongarra area, 132° 52′, 120° 50′, *M.O. Rankin 1947*, 18.iv.1979, flower and fruit (CANB, DNA); near East Alligator River 132° 5′, 12° 20′, *C.H. Gittins 2893*, 21.v.1975, flower and fruit (BRI); Myra Falls vicinity, Tin Camp Creek 12° 28′ S, 133° 20′ E, *T.G. Hartley 13796*, 29.v.1973, flower and fruit (CANB); near Buffalo Springs, Mt Brockman, 4 km NNE of Koongarra, *M. Lazarides 8917*, 22.v.1980 (CANB); Gulungul Creek on Arnhem Highway, 12° 39′ S, 132° 53′ E, *L.A. Craven 5553*, 18.v.1980 (CANB, 2 sheets); c. 16 km S of Oenpelli Mission, 12° 29′ S, 133° 03′ E, *L.G. Adams & C.R. Dunlop 2983*, 15.ii.1973 (CANB).

Affinities

The species is similar to *Trianthema pilosa* in leaf shape and indumentum, but the branches are longer and the nodes more distant. The flowers are large, solitary and pedicellate. The fruit is very distinctive with its thin-walled campanulate operculum with undulating rim and one seed twice as large as in *T. pilosa*.

Ecology

On all herbarium sheets available it is stated that the plant was collected in sandy soil.

It is curious to find that some of the seeds are hollow, but the phenomenon is not well understood especially as it cannot be attributed to insect attacks in the cases investigated.

Trianthema patellitecta Prescott, sp. nov.

Similis *T. pilosae* F. Muell. sed operculo patelliformi tecto membrana hyalina et seminis laevibus differt.

Type: Kimberley Research Station, W.A., *R.A. Perry 3067*, 26.vii.1952 (holotype: CANB 92755; isotypes: AD 96103192; BRI 177606; CANB 47388, NSW).

The specific epithet refers to the operculum which from the top resembles a dish covered with a hyaline membrane.

Description

Spreading prostrate herb with stems to 1 m long, with long internodes, hirsute with stiff spreading hairs on all parts. *Branchlets* distant, regularly alternate, or one long and one short per node. *Leaves* clustered, opposite, petiole c. 6 mm long, usually dilated into membranous sheath immediately below lamina, sheath on young leaves larger than lamina, ovate, winged at anterior edge, 3-veined; lamina flat, ovate, larger ones tending

Fig. 4. Holotype of the name *Trianthema patellitecta, Perry 3067* (CANB).

to oval or spathulate, 4-30 mm long x 3-15 mm wide, apex usually acute, mid-vein visible below. *Flowers* solitary or paired, sessile, axillary. *Perianth*: lobes 5, triangular-lanceolate, unequal, 2 with narrow scarious margins, 3 wider, dorsal horn if present small, not exceeding perianth, red or purple inside, c. 2.5 mm long; perianth tube obconical, c. 2 mm long. *Stamens* 15-25, c. 2 mm long; filaments filiform. *Ovary* cylindrical, c. 1.5 mm long, style 2 mm long, terete, sunk into central depression, ovules 2. *Fruit* dry, globe-shaped, dehiscing by circumscissal split about the middle; operculum dish-shaped with fine hyaline cover across top, c. 4 mm across; style persistent. *Seeds* 2, one remains at base of operculum and one at base of fruit, c. 1.5 mm broad, pea-shaped, faintly reticulate, finally shiny black but initially with hyaline cover. (Figs 1 & 4).

Distribution

North-western Australia. Known from only a few localities but could be more widespread in remote areas. (Map 3).

Specimens examined

WESTERN AUSTRALIA: Karunji Station, *D. Rust 21*, January, 1951, flower and fruit (PERTH); Kununurra, *D. Bedbrook 4E*, 29.ii.1972, flower (PERTH); 5 km SSE of Kununurra, 128° 45′ E, 15° 49′ S, *K. Paijmans 2325*, 10.iii.1978 (CANB, PERTH); N.W. Kimberley Research Station, Kununurra, 128° 40′ E, 150° 32′ S, *M.H. Andrew 169*, 7.xii.1978, flower and fruit (DNA); King River, W.A., *N. Byrnes NB 303*, 18.v.1967, fruit (DNA); Prince-Regent's River, W.A., *Bradshaw & Allen s.n.*, 1891, fruit (MEL, NSW); Kimberley Research Station, W.A., *R.A. Perry 3067*, 26.vii.1952 (AD, BRI, CANB, NSW); Hidden Valley, c. 3 km NE of Kununurra, East Kimberley, *R. Pullen 10.587*, 25.iv.1977 (NSW, CANB); Kimberley Research Station, *B.G.W. Drysdale 204*, 14.ii.1950, flower and fruit (PERTH, CANB); 30 km NNW Kununurra 128° 40′ E, 15° 32′ S, *M.H. Andrew 299*, 18.i.1979, flower and fruit (BRI); King River Pumping Station, W.A., *E.M. Bennett 1734*, 18.v.1967, fruit (PERTH); Kununurra, near Kimberley Research Station); *K.T. Richards 26*, 18.iii.1964, flower and fruit (PERTH); Kimberley Research Station, Ord River, *P.J. van Rijn s.n.*, 26.viii.1960, flower (PERTH); Karungie, *D.W. Rust 180*, 21.ii.1951, fruit (CANB); vicinity of Kimberley Research Station, near Kununurra, East Kimberleys, *D.H. Mackenzie 690312-27*, 1969, flower and fruit (CANB); 4 miles NE of Wyndham Pumping Station, W.A., 15° 30′ S, 128° 05′ E, *J.R. Maconochie 121*, 18.v.1967 (CANB); Townside, c. 12 miles from the Station, *P.J. van Rijn 14*, 12.v.1960, flower and fruit (CANB).

NORTHERN TERRITORY: Jasper Gorge, Victoria River Downs area, N.T. 130° 45′ E, 16° 02′ S, *B.J. Ganley s.n.*, 19.vii.1964, fruit (NT).

Affinities

This species is similar to *Trianthema pilosa* in leaf shape and indumentum but the fruit is very distinctive, because the operculum from the top resembles a dish covered with a hyaline cover. The seeds are smooth and without papillae. The habit appears to be slightly different with long internodes and leaves clustered on branchlets. These leaves are quite uniform in size and shape with lamina c. 5 mm long.

Ecology

The species is usually associated with sand near rivers. The notes available on herbarium sheets are: 'sandy embankment in sandstone cliff complex', 'sandstone hills', 'cockatoo sand', 'red levee sand', 'growing in gorge close to water', 'moist edge of herbaceous swamp within sandy savannah country', 'sandy river alluvium', 'loamy river levee soil', 'disturbed cultivated strip of cockatoo sand'.

Map 1. Distribution of *Tetragonia cristata*.
Map 2. Distribution of *Trianthema megasperma*.
Map 3. Distribution of *Trianthema patellitecta*.

Acknowledgements

I would like to thank the Australian Biological Resources Study for financial assistance during the preparation of the flora treatment; Dr John Jessop for his supervision; Dr Jackie Venning for her support during the work; Kathy Stove for photographing the types and Miss Barbara Welling for typing the manuscript.

References

Bentham, G. (1867). "Flora Australiensis". 3: 331 (Reeve: London).
Mueller, F. (1859). "Fragmenta Phytographiae Australiae". 1: 173-175 (Government Printer: Melbourne).
Mueller, F. (1876). "Fragmenta Phytographiae Australiae". 10: 83 (Government Printer: Melbourne).
Mueller, F. (1884). Definitions of some new Australian plants. *Sc. Rec.* 3(12): 282.
Mueller, F. (1895). Description of hitherto unknown plants from north-western Australia. *Chem. & Druggist Austral.* 10: 207.
Ostenfeld, (1921). Contributions to West Australian Botany. *Biol. Meddel. Kongel. Danske Vidensk. Selsk.* 3, 2: 59.
White, C.T. (1919). Contributions to the Queensland flora. *Queensland Dept. Agriculture Bot. Bull.* 21: 10.

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NOTONERIUM (APOCYNACEAE) LAID TO REST IN THE BORAGINACEAE

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Abstract

Notonerium gossei (Apocynaceae) is shown to be a species of *Heliotropium* (Boraginaceae).

A long standing mystery in the flora of Central Australia has been the precise identity of the monotypic genus *Notonerium* Benth. It was discovered in 1873 by W.C. Gosse during his Central Australian expedition, when he travelled north from Alice Springs to the Reynolds Range and then turned south through the MacDonnell Range to discover Ayers' Rock and the Mann, Tomkinson and Musgrave Ranges which extend along the present South Australian/Northern Territory border (Feeken et al., 1970). Whether or not Gosse recorded the exact locality at which he collected *Notonerium*, it is unknown today, which is unfortunate because Gosse's specimen is possibly the only one of this species ever collected.

Gosse's specimen was given to Dr Richard Schomburgk, Director of the Adelaide Botanic Garden, who in turn sent it to George Bentham at Kew. Apparently Schomburgk did not keep any part of the specimen for himself. Bentham (May 1876 a & b) described and named the new genus *Notonerium* simultaneously in two publications. He gave it the specific name of *N. gossei* (Bentham, May 1876 b), after its discoverer. He placed it in the family Apocynaceae, but with some uncertainty because the specimen lacked mature fruits.

Meanwhile Mueller (1877) reported a second collection of *N. gossei* made by Mr E. Giles in the Musgrave Range. I have not seen Giles' specimen, and do not know whether Mueller's identification was correct. Mueller could not have seen the type of *N. gossei*, which was by then in London.

Stapf (1915) was the first to recognise that *Notonerium* had been placed in the wrong family. He transferred it to the Boraginaceae, making the new combination *Heliotropium gossei* (Benth.) Stapf. Bentham had completely overlooked the distinctively stiff hairs, a feature which the Apocynaceae lack, and which characterises the Boraginaceae. Moreover, Bentham (May 1876 b) had observed that the ovary was apparently 4-locular but speculated that this may have been "the moieties of 2 carpels with deep dorsal furrows between the ovules". The Apocynaceae have an ovary of two carpels and only one or two cells, whereas the Boraginaceae have an ovary of two carpels usually divided into four cells by false septa. Stapf observed that the type of *N. gossei* was "very scanty", certainly no exaggeration, and charitably suggested that this accounted for its placement in the wrong family. Unfortunately Stapf's new combination was overlooked by Australian botanists and subsequent flora treatments (Black 1926, 1957; Jessop et al., 1981) use the original name of *Notonerium gossei* and retain the genus in the Apocynaceae. Even the compilers of important reference works such as Farr et al. (1979), Jackson et al. (1893-1981) and Willis (1973) seem to have overlooked Stapf's paper. Acting on advice received from the present author this has been rectified in Morley and Toelken (in press).

In recent years, the enigma of a genus known perhaps only from the type collection,

with no precise locality, has come to the attention of conservationists. Currently it is regarded as possibly threatened but insufficiently known for its exact status to be determined (Leigh et al., 1981).

Following a number of recent enquiries about *Notonerium* at the Adelaide (AD) herbarium, the Chief Botanist, Dr John Jessop, asked me to locate its type at Kew (K) and check its identity. A cross reference in the Kew herbarium from the Apocynaceae to the Boraginaceae led me to the type (Fig. 1) and Stapf's (1915) paper in which he made the new combination, *Heliotropium gossei.*

Stapf (1915) states that *H. gossei* has affinity with *H. tenuifolium* R. Br. but differs in being less canescent, in having the stamens inserted much lower on the corolla tube, in the capitate shape of the stigma, and in the nutlets being minutely and sparsely setose. In checking the diagnosis, I found that the type material of *H. gossei* is indeed very scanty. The specimen (Fig. 1) appears to be immature, just coming into flower. Many branchlet apices have been broken off, and there is an envelope attached to the sheet containing loose fragments of several dissected flowers but I could find no style or stigma, and no mature fruits. On the last character there is a curious inconsistency between the papers of Bentham (May 1876 a & b) and that of Stapf (1915). Bentham

Fig. 1. Holotype of *Notonerium gossei* Benth. in K (= *Heliotropium gossei* [Benth.] Stapf).

laments a lack of mature fruit on the type specimen, whereas Stapf describes and illustrates nutlets. I can now find no such nutlets on the specimen.

The characters of the insertion of the stamens, the indumentum and the shape of the stigma (as illustrated by Bentham [May 1876 b] and Stapf [1915]) do indeed separate *H. gossei* from *H. tenuifolium*. At Kew, there is a large collection of specimens under the name *H. tenuifolium* (including the type) showing a great deal of heterogeneity, but none match the type of *H. gossei*. The type of *H. gossei* does not key out nor does it fit the descriptions of any species in the treatment of *Heliotropium* in Jessop et al. (1981). Thus it appears that *H. gossei* may be a distinct species, although it is essential to match the type with another, better specimen before its identity and rarity can be finally resolved. However it is quite clear that *Notonerium* must fall into the synonymy of *Heliotropium*.

Acknowledgement

I would like to thank Dick Brummitt for his advice about *Heliotropium*, and for reading the manuscript.

References

Bentham, G. (May 1876 a). In Bentham, G. & Hooker, J.D., "Genera Plantarum" 2: 698-699. (Reeve: London).
Bentham, G. (May 1876 b). *Hook. Ic. Pl.* 12: 70, t. 1180.
Black, J.M. (1926). "Flora of South Australia" Part 3, 462. (Govt Printer: Adelaide).
Black, J.M. (1957). "Flora of South Australia" ed. 2, part 4, 696. (Govt Printer: Adelaide).
Farr, E.R., Leussink, J.A. & Stafleu, F.A. (1979). "Index nominum genericorum (Plantarum)" 2: 1185. (Junk: The Hague).
Feeken, E.H.J., Feeken, G.E.E. & Spate, O.H.K. (1970). "The discovery and exploration of Australia". (Nelson: Melbourne).
Jackson, B.D. et. al. (1893-1981) "Index Kewensis". 2 vols & suppl. 1-16. (Univ. Press: Oxford).
Jessop, J.P. et al. (eds.) (1981). "Flora of Central Australia". (Reed: Sydney).
Leigh, J.H., Briggs, J. & Hartley, W. (1981). "Rare or threatened Australian plants". Austral. Natn. Parks Wildl. Serv. Spec. Publ. 7 (Canberra).
Morley, B. & Toelken, H. (in press). "Flowering Plants in Australia". (Rigby: Adelaide).
Mueller, F.J.H. von (1877). List of the plants obtained during Mr E. Giles' travels in Australia, 1875 & 1876. *J. Bot.* (*London*) 15: 305.
Stapf, O. (1915). *Hook. Ic. Pl.* 31: t. 3006.
Willis, J.C. (1973). "A dictionary of the flowering plants and ferns". ed. 8: 800. (Univ. Press: Cambridge).

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ADDITIONS TO 'THE SPECIES OF *CRASSULA* L. IN AUSTRALIA'.

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Abstract

Crassula sieberiana subsp. *rubinea* Toelken is described from New South Wales. The combination *C. colorata* var. *acuminata* (Reader) Toelken is published and *C. ciliata* L. is recorded as naturalised in South Australia. Notes and additions to the previously published key (Toelken, 1981) are included.

Since the recently published revision of the genus *Crassula* in Australia (Toelken, 1981) important additional information has come to hand. The format employed here and retention of the species numbering enables the additions to be collated in the previous work.

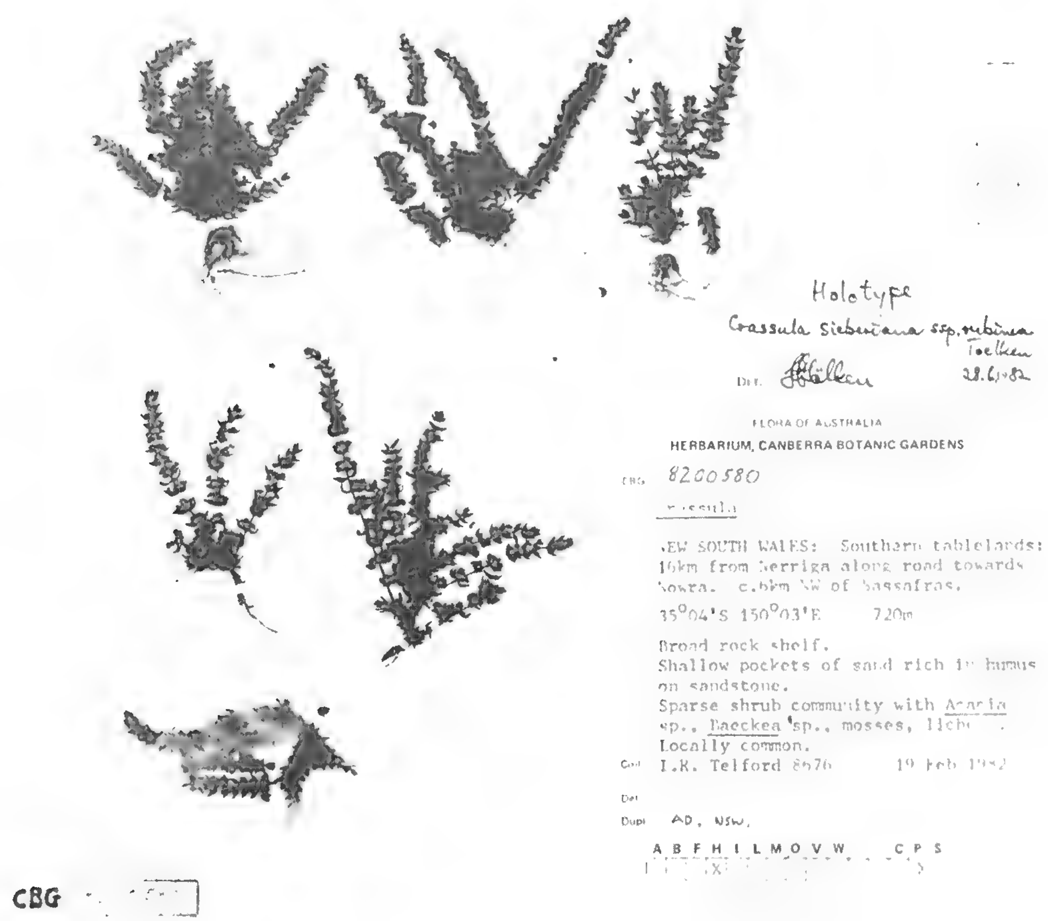

Fig. 1. *Crassula sieberiana* subsp. *rubinea*: holotype *Telford 8676* (CBG).

I. In the paper attention is drawn to particularly robust plants of *C. sieberiana* subsp. *sieberiana* from near Nerriga. As a result of an investigation of this complex in the field, these are now regarded as forming separate subspecies.

9c. C. **sieberiana** subsp. **rubinea** Toelken, subsp. nov.

Ab subsp. *sieberiana* foliis rubineascentibus, vaginis foliorum latioribus (0.5-0.7 mm), petalis sepalis aequantibus fructu; ab subsp. *tetramera* habitatu perenni, ramificanti a base, petalis sepalis aequantibus fructu differt.

Herba perennis, rare annua, ramis erectis sed interdum radicibus adventiis a nodis infernis. *Rames* praecipue a base, carnosi, nodis aliquantum tumidis, foliis veteribus rare deciduis et internodiis basalibus rare longioribus foliis subtentis. *Folia* rubineascentia; vaginae 0.5-0.7 mm latae. *Petala* sepala circiter aequantia fructu. *Folliculi* secus suturas totas findentes et late effusi.

Type: New South Wales, 16 km from Nerriga on road to Nowra, *Telford 8676* (CBG, holo.; AD, CHR, K, L, MO, NSW, iso.).

Perennials, rarely annuals, with erect branches but sometimes with adventitious roots from the lower nodes. *Branches* mainly from the base, carnose, with somewhat swollen nodes, old leaves rarely deciduous and basal internodes rarely longer than the subtending leaves. *Leaves* becoming deep ruby-red; sheath 0.5-0.7 mm broad. *Petals* about as long as sepals when fruiting. *Follicles* spitting along whole suture and opening widely. Fig. 1.

Growing on shallow soil on top of sandstone shelves; recorded only from the vicinity of Nerriga.

In accordance with the change of the International Code as adopted at the International Botanical Congress in 1981 the specific epithet should be spelled 'sieberiana' and not 'sieberana' (article 73).

Table 1. Distinguishing characters of the subspecies of *Crassula sieberiana*.

	subsp. rubinea	subsp. sieberiana	subsp. tetramera
habit	perennial tufts	decumbent or prostrate perennials	annual tufts, rarely decumbent
branches	mainly basal with swollen nodes	irregularly branched with swollen nodes	few, irregular without swollen nodes
adventitious roots	rarely at basal nodes	often along branches	absent
basal internodes	2-4 (-5) mm	(1-) 3-5 (-8) mm	(4-) 8-12 (-20) mm
leaf colour change	ruby-red	brownish-red	pinkish to brownish-red
leaf sheath	(0.4) 0.5-0.7 mm	0.2-0.3 (-0.4) mm	0.2-0.6 (-0.8) mm
petal length	c. as long as sepals	c. $^2/_3$ of sepals	usually less than $^1/_2$ of sepals
habitat	shallow soil on rocks, well exposed position	shallow soil on rocks sheltered by rocks or vegetation	shallow or deep sandy soil, more or less sheltered

Subsp. *rubinea* is very similar to and could easily be interpreted as a robust form of subsp. *sieberiana* (cf. Toelken, 1981) unless one had the opportunity, as was subsequently provided at the type locality of subsp. *rubinea*, to investigate specimens of all three subspecies growing close to one another. The characteristics of all three subspecies are summarized in Table 1.

No difficulty was experienced in recognising the three taxa in the field by the tabulated characters but in cultivation the difference seem to be obscured as all plants have soft branches which are decumbent to prostrate and relatively shorter leaves in

comparison with the internodes which they subtend. Subsp. *tetramera* can, however, be distinguished by its very long basal internodes, which are up to eight times longer than the subtending leaves while they are rarely more than twice as long in the other two subspecies. Of the latter subsp. *rubinea* is distinguished from the subsp. *sieberiana* by its broader leaf sheath (see Table 1). In dried specimens of cultivated material, as well as those from the field, the nodal tissues did not collapse as much as those of the internodes so that a distortion of the membranous sheath can often be observed. In that case some identifications can be made by means of the length of the sepals relative to the petals (see Table 1). It was noticed that this ratio did not usually change as much from the flowering to fruiting stage in cultivated plants as it did in plants from the natural habitat. However, in cultivated plants some specimens were observed with an intermediate range of perianth size between subspecies.

Selection of specimens examined

NEW SOUTH WALES: *Adams 1470*, 4 miles E Nerriga (CANB); *Pickard 3319*, 1 km S Round Hill (NSW); *Toelken 7053*, 16 km from Nerriga on road to Nowra (AD).

Mr T.D. Stanley, Queensland Herbarium correctly pointed out in a personal communication that flowers of *C. sieberiana* subsp. *sieberiana* are predominantly 5-merous in Queensland. Couplets 11 and 12 of the key (Toelken, 1981; p. 65) need to be replaced and 11a, 11b and 12a added. This allows also for an extra lead to *C. decumbens* var. *decumbens* which has some plants with 4-merous flowers:-

11. Lateral part-inflorescences stalked. .... 7. *C. decumbens* var. *decumbens*
11. Lateral part-inflorescences sessile in axile of leaves.......... 11a
11a. Annuals with few branches from erect main axis; at least some lower internodes more than 3 times longer than the subtending leaves. .... 9b. *C. sieberiana* subsp. *tetramera*
11a. Perennials, rarely annuals, with branches mainly from the base; internodes rarely exceeding twice the length of the subtending leaves. 11b
11b. Leaf sheath 0.2-0.3 (-0.4) mm long; leaves turning brown, rarely brownish-red; in sheltered and usually shaded crevices.......... 9a. *C. sieberiana* subsp. *sieberiana*
11b. Leaf sheath (0.4-) 0.5 (-0.7) mm long; leaves turning deep ruby-red; in exposed positions on top of rock shelves. .... 9c. *C. sieberiana* subsp. *rubinea*
12. Perennials with thickened basal stems and often swollen nodes; Queensland. .... 9a. *C. sieberiana* subsp. *sieberiana*
12. Annuals with thin wiry stems without thickened nodes; Australia south of Queensland 12a
12a. Flowers sessile or almost so 13
12a. Flowers with pedicels at least 1.5 mm long.......... 16

II. In a re-evaluation of the type specimen of *Tillaea acuminata* the existing combination *C. colorata* var. *acuminata* should have been adopted in preference to *C. colorata* var. *tuberculata* (cf. Toelken, 1981):

11c. **C. colorata** (Nees) Ostenf. var. **acuminata** (Reader) Toelken, comb. nov.

Type: Victoria, Dimboola shire, Lowan, *Reader in MEL 89418a* (MEL, holo.!).

Tillaea acuminata Reader, Vict. Nat. 15: 96 (1898).

T. sieberiana J.A. & J.H. Schultes var. *acuminata* (Reader) Ewart et al., J. Proc. R. Soc. N.S.W. 43: 196 (1908).

Crassula sieberiana (J.A. & J.H. Schultes) Druce var. *acuminata* (Reader) Domin, Bibl. Bot. 89: 704 (1925).

Crassula colorata (Nees) Ostenf. var. *tuberculata* Toelken, J. Adelaide Bot. Gard. 3: 81 (1981), nom. illeg.

Type: Western Australia, 65 km NNW Leonora, *Toelken 6079* (AD, holo.!).

III. Since the publication of a revision of the genus *Crassula* in Australia (Toelken, 1981) a population of several plants of *Crassula ciliata* from near Yankalilla (South Australia) has been found and the species must be interpreted as naturalised there. Insert additional couplet between couplets 1 and 2 of the key (Toelken, 1981, p 64):-

1a. Leaves with dense row of spreading marginal cilia . . . (sect. *Subulares*) .... 15. *C. ciliata*

1a. Leaves glabrous 2

E. sect. **Subulares** Haw. ex DC., Mem. Coll. 2. Crassulacees 17 (1828), partly; Toelken, Contr. Bolus Herb. 8: 286 (1977).

Type Species: *C. ramosa* Thunb.

Perennial shrublets with base somewhat woody. *Leaves* dorsiventrally compressed, glabrous except for marginal cilia. *Inflorescence* a terminal thyrsoid, with more or less distinct peduncle as leaves are gradually shortened upwards; flowers tubular. *Calyx* shorter than corolla. *Carpels* with elongate ovaries more or less abruptly tapering into styles.

Species occur naturally in the winter rainfall region of the south-western to south-eastern Cape Province, South Africa.

15. **C. ciliata** L., Sp. Pl. ed. 1: 283 (1753); DC., Hist. Pl. Succ. t. 7 (1799); Toelken, Contr. Bolus Herb. 8: 293 (1977).

Type: Dillenius, Hort. Eltham., 116, t. 98, fig. 116.

Perennial shrublets to 40 cm high when flowering, moderately branched from the base. *Leaves* oblong-elliptic 1.5-3 x 0.5-0.8 (-1.2) cm, obtuse or rounded, slightly constricted towards the base, dorsiventrally flattened, erect, with a dense row of spreading marginal cilia, green to yellowish-green. *Inflorescence* a rounded or flat-topped thyrsoid borne above the leaves; flowers 5-merous. *Calyx*: lobes triangular 2-3 mm long, acute to obtuse, slightly fleshy, green to yellow. *Corolla* urceolate later campanulate, white to cream; lobes ovate-rostrate, c. 3 mm long, drawn into a blunt point, without dorsal appendage, first erect later recurved. *Squamae* oblong 0.9-1.2 x c. 0.3 mm, truncate to slightly emarginate, scarcely constricted downwards, fleshy, pale yellow. *Ovaries* oblong-reniform, more or less abruptly constricted into slender styles, with 8-12 ovules. *Follicles* erect, smooth, dehiscing by apical pore.

Native along the southern Cape coast, South Africa; now found naturalised near Yankalilla cemetery (Southern Lofty region of South Australia) where it is growing on dry flats.

Specimen examined

SOUTH AUSTRALIA: *Symon 12963*, near Yankalilla cemetery (AD, ADW).

Acknowledgements

The author is indebted to Mr D.E. Symon for drawing his attention to a population of *C. ciliata* near Yankalilla. Mr T.D. Stanley pointed out that *C. sieberiana* subsp. *sieberiana* has mainly 5-merous flowers in its few occurrences in southern Queensland. Mr I. Telford kindly collected sufficient material for an adequate type specimen of *C. sieberiana* subsp. *rubinea*.

Reference

Toelken, H.R. (1981). The species of *Crassula* L. in Australia. *J. Adelaide Bot. Gard.* 3: 57-90.

J. Adelaide Bot. Gard. 6(2): 197-200 (1983)

A PUTATIVE HYBRID BETWEEN *PTEROSTYLIS CURTA* AND *P. PEDUNCULATA* (ORCHIDACEAE) FROM SOUTH AUSTRALIA

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and

J. Z. Weber
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Adelaide, South Australia 5000

Abstract

A putative naturally occurring hybrid between *Pterostylis curta* R. Br. and *P. pedunculata* R. Br. is reported from two localities near Adelaide. The validity of previous reports of this hybrid is discussed and the characteristics of the putative hybrids and its parents are tabulated as well as illustrated.

Discussion

A population of the putative hybrid between *Pterostylis curta* R. Br. and *P. pedunculata* R. Br. was discovered by R. Bates in the Belair Recreation Park (south of Adelaide) in September 1979 and observed for several seasons since then. One hundred years earlier R.D. Fitzgerald (1879) illustrated a plant from New South Wales which he suggested was a hybrid between *P. curta* and *P. pedunculata* but Dockrill (1969) and Clemesha (1972) referred this illustration to *P. hildae* Nicholls. This latter view is accepted here as Fitzgerald's plant has narrow lateral sepals which are shorter than the galea and an acute, not twisted labellum which clearly protrudes from the flower. These are features of *P. hildae* but not of the hybrid. *P. hildae* occurs in Queensland and north-eastern New South Wales, mainly near the coast where it is a widespread species not associated with either *P. curta* or *P. pedunculata*. It has not been recorded from South Australia.

P. curta and *P. pedunculata* are widely distributed through south-eastern Queensland, New South Wales, Victoria and Tasmania. In South Australia both species are found in the northern Lofty, southern Lofty and South-Eastern regions. *P. pedunculata* has also been recorded from the southern Yorke Peninsula and Kangaroo Island (cf. Map 2). Both species generally occur in dense colonies and flower between August and October. *P. curta* is restricted to deeply shaded gullies and creek banks but *P. pedunculata*, although commonly occurring with *P. curta* in these habitats, is also found in heath or mallee heathlands and open forests in clay, sandy or calcareous soils in South Australia (Markwick & Bates, 1982). Willis (1962) observes that *P. curta* is widespread in Victoria (woodlands) and that *P. pedunculata* is ". . . more abundant on sandy ground under coastal tea-tree scrub but extending into mountain forests and even shaded fern gullies".

It is in this last habitat that the two species occur, together with a colony of about one hundred plants of the putative hybrid in the Belair Recreation Park in the Mt Lofty Range. Much of the information presented here is based on several years observation of this colony. As there is little morphological variation in the hybrid plants and they all grow in one dense colony it is probable that the population is derived from a single hybrid ancestor by cloning. The hybrid plants generally produce 2-3 tubers annually.

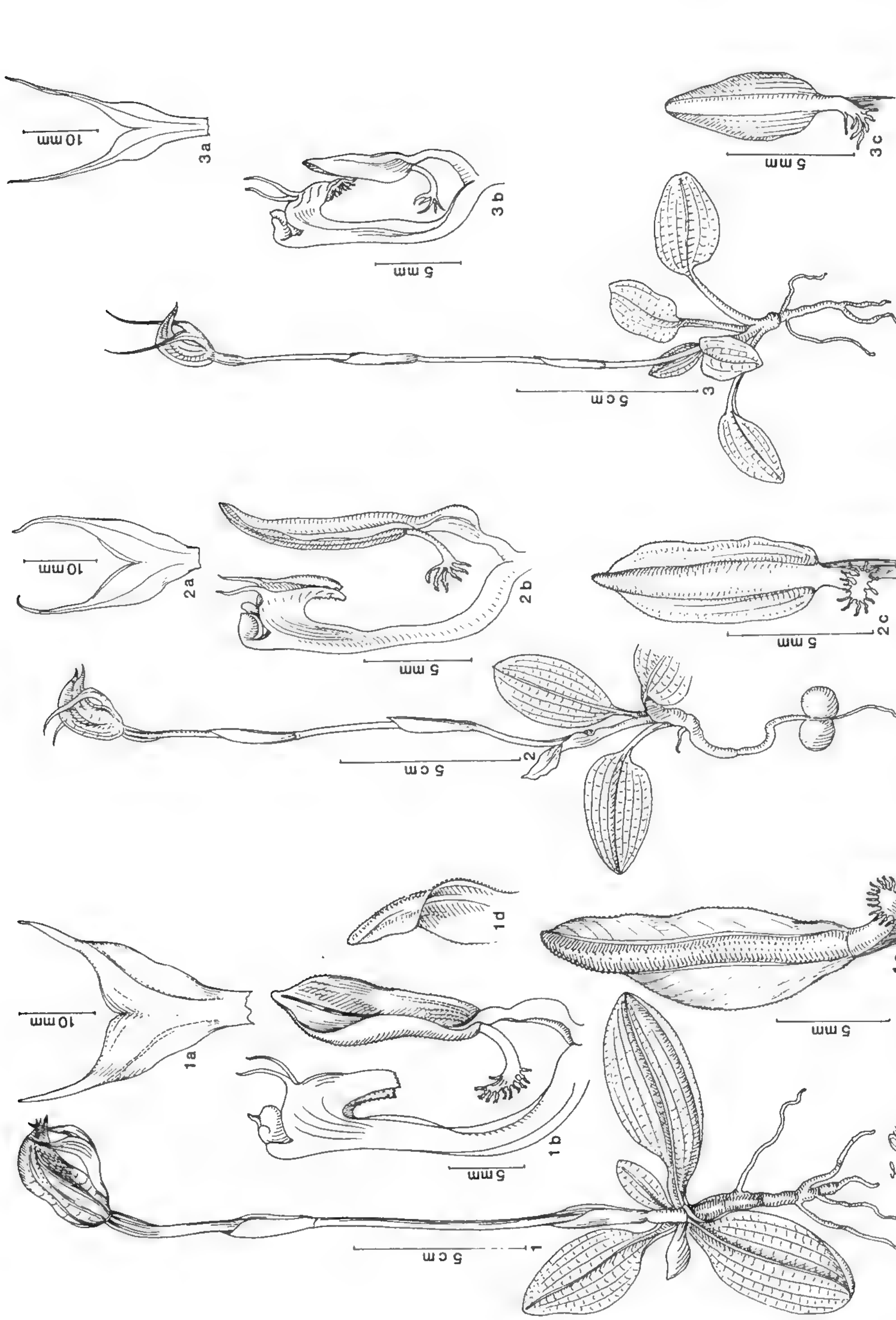


Fig. 1-3. 1. *P. curta*, plant; 2. Putative hybrid between *P. curta* and *P. pedunculata*, plant; 3. *P. pedunculata*, plant. (a. partly fused lateral sepals; b. column and labellum in side view; c. labellum in front view; d. tip of labellum).

So far, 35 plants of the putative hybrid have been collected from two localities in this region. Eight plants were collected by Miss Verena Jacobs (23.ix.1915) from Cherry Gardens. R. Rogers noted their similarity to *P. curta* and *P. pedunculata* and, in fact, suggested on the sheet that they were hybrids. R. Bates (15.ix.1980, 9.ix.1981 and 8.ix.1982) collected a total of 27 specimens from the Belair Recreation Park. The specimens from the 1981 collection were used for the illustrations.

During observations of the colony two species of Mycetophilid flies (fungus gnats) were found visiting the hybrids, although neither was observed to transfer pollinia. The larger of the two flies was observed to be a possible pollinator for *P. curta* in the area and was also observed on the flowers of *P. pedunculata*; its large size, however, prevented it from entering the narrow galea of these flowers. The smaller fly was observed entering the flowers of *P. pedunculata* and removing the pollinia but was not seen to enter flowers of *P. curta* although it is possible that it does so. The small size of this fly would perhaps prevent its removing pollinia from the larger flowers of *P. curta*, but if a fly bearing pollen massulae from *P. pedunculata* were to enter a flower of *P. curta* there is no barrier to prevent transfer of pollen to the stigma. Observations indicate that this would be an uncommon occurrence.

Structurally there is little chance of self fertilisation occurring in the putative hybrid or the parent species. A count of 100 withered flowers of each species in the area showed that only 35 of the *P. curta* flowers were setting seed and 27 of the *P. pedunculata.* None of the putative hybrid plants have yet been observed to produce seed. Judging by the uniformity of the hybrids it seems that backcrossing is not taking place.

Many artificial hybrids of *Pterostylis* species have been produced (Bates, 1981; Stoutamire, 1982) but to our knowledge the above hybrid is not one of these. Stoutamire (l.c.) stated that "crossing *Pterostylis curta* and *P. pedunculata* resulted in few seeds with poorly developed embryos. Some of these germinated but seedlings died in flask." It is possible that the crossing occurs more commonly in nature but poor seed viability may be responsible for the apparent rarity of hybrid plants.

Both species, *P. curta* and *P. pedunculata*, as well as the hybrid are illustrated in Figs. 1-3 and their morphological characteristics summarised in Table 1.

Table 1. Diagnostic features of *P. curta*, putative hybrid and *P. pedunculata*. (Based on the specimens from the Belair Recreation Park collected by Bates in 1980 and 1981).

Feature	P. curta	Putative hybrid	P. pedunculata
Basal leaves	3-6 cm long, elliptical to oblong-elliptical, 2-6 on long petioles.	3-5 cm long, ovate, 2-5 on long petioles.	2-3 cm long, ovate to oblong, elliptical, 2-4 on long petioles.
Stem at flower	c. 2 mm diam.	c. 2.5 mm diam.	c. 3 mm diam.
Flower	greenish and white	green with a rusty coloration about the apex of the galea.	green with dark brown coloration about the apex of the galea and sinus of the lower lip.
Hood (Galea)	3-3.5 cm long	c. 2.2 cm long	c. 1.3 cm long
Lateral sepals	with sinus, 120-180° wide; the lobes not as long as the galea.	with sinus 90-110° wide; the lobes about as long as the galea.	with sinus c. 75° wide; the lobes much longer than the galea.
Labellum	rusty coloured, c. 14 mm long, oblong linear but twisted and wider toward the apex, almost acute and projecting through the sinus.	brown, c. 9 mm long, oblong-elliptical, slightly twisted, obtuse, reaching just level with the sinus.	dark brown, c. 5.5 mm long, bluntly ovate, not reaching the sinus.
Column	c. 20 mm long	c. 15 mm long	c. 11 mm long
Stigma	linear elliptical	elliptical	ovate

Selected South Australian specimens housed at AD were examined.

P. curta (From Belair Recreation Park): *H.A. Gunter s.n.*, 30.ix.1929, Long Gully; *R.S. Rogers 4032*, 27.viii.1909, National Park Belair; *S.A. White s.n.*, 19.vii.1906, National Park.

P. pedunculata (From Belair Recreation Park): *R.S. Rogers s.n.*, 22.viii.1905, National Park Belair; *S.A. White s.n.*, 19.vii.1906, Long Gully; *S.A. White s.n.*, early 20th Century, National Park Belair.

Putative hybrids (From Belair Recreation Park and vicinity): *R. Bates s.n.*, 15.ix.1980, Belair Recreation Park; *R. Bates s.n.*, 9.ix.1981, Belair Recreation Park (Voucher specimens of hybrid and parent species, also in wet collection at AD); *R. Bates 2252 & 2253*, 8.ix.1982, Belair Recreation Park; *V. Jacobs* sub *R.S. Rogers 4147*, 23.ix.1915, Cherry Gardens.

References

Bates, R. (1981). Man made Australian terrestrial orchid hybrids. *J. Native Orchid Soc. S. Aust.* 5: 82.

Bates, R. & Weber, J.Z. (1979). Putative hybrid between *Prasophyllum archeri* and *P. despectans*. *J. Adelaide Bot. Gard.* 1(6): 357-360.

Clemesha, S.C. (1972). *Pterostylis hildae* Nicholls. *Orchadian* 4: 30.

Dockrill, A. (1969). 'Australian Indigenous Orchids' vol. 1. (Soc. for Growing Aust. Plants: Sydney).

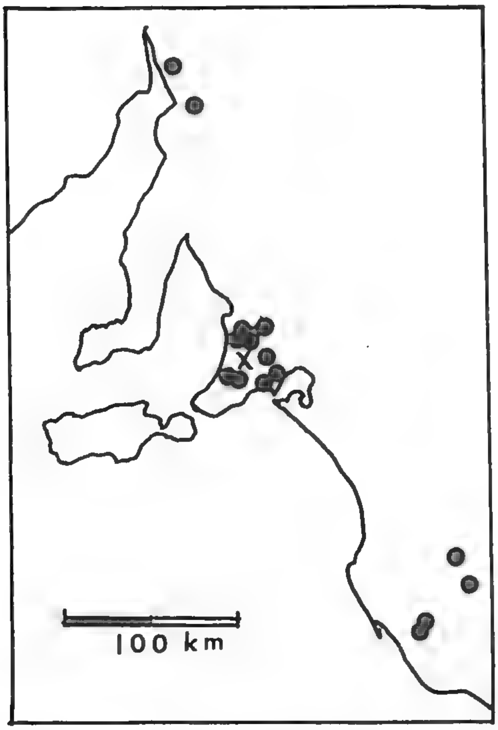
Fitzgerald, R.D. (1879). 'Australian Orchids' 1(5). (Govt Printer: Sydney).

Markwick, R.J. & Bates, R.J. (1982). 'Phytogeography of South Australian Orchidaceae'. (Manuscript of Native Orchid Soc. S. Aust.).

Stoutamire, W. (1982). Australian *Pterostylis*—the Greenhoods. *Amer. Orchid Soc. Bull.* 51(8): 796-803.

Weber, J.Z. & Bates, R. (1978). In Jessop, J.P. 'J.M. Black's Flora S. Aust. ed. 3, 1. (Govt Printer: Adelaide).

Willis, J.H. (1962). 'A Handbook to Plants in Victoria' 1. (University Press: Melbourne).



Map 1. Distribution of *P. curta* in South Australia (X denotes putative hybrid).

Map 2. Distribution of *P. pedunculata* in South Australia.

J. Adelaide Bot. Gard. 6(2): 201-202 (1983)

A NEW SPECIES OF *ACACIA* FROM THE NORTHERN TERRITORY

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Abstract

Acacia jasperensis J.R. Maconochie, a new species restricted to Jasper Gorge, Northern Territory, is described. Its distinguishing features from *A. alleniana* and *A. praelongata* are discussed.

Acacia jasperensis J.R. Maconochie, sp. nov.

Frutex ad 6 m altus. *Phyllodia* erecta, filiformia, puncticulata, teretia, 8.5-15 cm longa, 0.5-0.7 mm lata. *Flores* 5-meri; lobi calycis spathulati, 0.9-1 mm longi; corolla glabra, 1.2-1.5 mm longa; ovarium glabrum. *Legumen* planum, glabrum, chartaceum, 6-10 cm longum, 8-12 mm latum. *Semina* subglobosa, 4-4.5 mm diametro.

Type: *J.R Maconochie 2631*, 30.iii.1981, Jasper Gorge, 16° 02′ S, 130° 47′ E (NT, holo.; AD, BRI, CANB, CBG, DNA, K, MEL, MO, NSW, iso.).

Erect slender shrub or tree to 6 m high, with smooth grey bark. *Phyllodes* erect, filiform, punctulate, terete, or quadrangular when dry, 8.5-15 cm long, 0.5-0.7 mm broad, with raised circular gland surrounded by dark ring of tissue 5-6 mm from base. *Inflorescence* spherical 3-5 mm diameter, in groups of 3 or 4 in axils of phyllodes; flowers yellow; peduncles glabrous, 8-10 mm long. *Calyx* free, with lobes spathulate, sparsely hairy, 0.9-1 mm long. *Corolla* glabrous, with apices of lobes thickened, 1.2-1.5 mm long. *Ovary* glabrous. *Pods* flat, glabrous, slightly glaucous, papery, prominently domed above each seed and slightly contracted between them, 6-10 cm long, 8-12 mm broad. *Seeds* subglobular, 4-4.5 mm in diameter. Fig. 1.

Only known from the type locality, Jasper Gorge.

Specimens examined

NORTHERN TERRITORY: Jasper Gorge, *A.S. George 15138*, 15.vi.1978 (NT); *J.R. Maconochie 2491*, ix.1980 (NT).

Affinities

A. jasperensis is allied to *A. alleniana* Maiden and *A. praelongata* F. Muell. *A. praelongata* differs from *A. jasperensis* in having longer and broader phyllodes (110-250 x 1-4 mm) and a compound inflorescence. *A. alleniana* and *A. jasperensis* are very similar in general morphology and habitat; both species grow on rocky hillsides and flowering specimens are indistinguishable except for the presence of a circular gland at the base of the phyllodes of *A. jasperensis*. These two species are distinguished as follows:

Phyllodes with circular gland near base; pod flat, smooth, 60-100 x 8-12 mm, glaucous; seeds subglobular, 4-4.5 mm in diameter .... *A. jasperensis*

Phyllode without gland; pod flat, reticulate, 70-150 x 3.5-5 mm, not glaucous; seeds cylindrical, 2-2.5 x 4 mm .... *A. alleniana*

Fig. 1. Holotype of the name *A. jasperensis*, *Maconochie 2631*, (NT).

J. Adelaide Bot. Gard. 6(2): 203-205 (1983)

PLANT PORTRAIT

9. Amorphophallus campanulatus (Roxb.) Bl. ex Decne. (Araceae).

Amorphophallus campanulatus (Roxb.) Bl. ex Decne., *Nouv. Ann. Mus. Hist. nat. (Paris) ser.* 3, 3: 366 (1834).

Basionym: *Arum campanulatum* Roxb., Hort. Beng. 66 (1813).

Ic. (selected): Roxb., Pl. Corom. 3, t. 272 (1819); Hook., Curtis's bot. Mag. t. 2812 (1828); Blume, Rumphia 1, t. 32, 33 (1835); Wight, Ic. Pl. Ind. Or. 3, t. 782, 785 (1843-45); Hook. f., Curtis's bot. Mag. t. 6978 (1888), as *A. virosus* N.E. Br.; Engl., Pflanzenfam. 2, 3: 127 (1889) and Pflanzenreich 23C: 76, fig. 27 (1911), same illustration but now as *A. rex* Prain ex Hook. f.; F.M. Bailey, Qd Agric. J. n. ser. 1, t. 15, 16 (1914).

The illustration is largely based on *Must 1154* (CANB, DNA, K, NT) as well as on the photograph and description published by Harmer (1976). The identification of this specimen was checked at Kew.

Perennial herb with often a large, somewhat flattened tuber from which early in the season an inflorescence and later a compound leaf is produced. *Leaves* 1-1.5 m long, with a stout petiole less than half as long and irregularly spotted; lamina deeply dissected into 3-5 main raches, each usually at least once more dichotomously divided and pinnately dissected, or lobed towards the apices, and often with only a narrow ridge or wing of leaf tissue connecting the lobes; leaflets or lobes lanceolate-elliptic, rarely ovate, more or less acuminate especially terminal ones. *Inflorescence* 20-40 cm long with usually three pale bracts on the basal stalk and one large coloured one (= spathe) sheathing the lower part of the spadix; in flowering stage spathe forming an obconical cup around the spadix, with the margins and the larger terminal point spreading or later reflexed and more or less flabby-undulate, deep purplish-maroon on top abruptly changing to yellow inside the cup; spadix ending in a deep maroon, cone-like appendage, often with a few irregular folds particularly when older, overtopping and broader than numerous simple male flowers (above) and female flowers (below) on the thinner floral axis; male portion of spadix consists of numerous two lobed anthers each of which is sometimes widened upwards and dehisces towards the apex; female portion of spadix is longer and consists of numerous pistils each with a sessile 2-3 loculed ovary surmounted by a style at least three times as long, terminating in a prominent tri-, rarely bilobed stigma, distinctly papillose. *Fruits* fleshy, orange-red.

The impressive flowering inflorescences of *A. campanulatus* deserve to be illustrated again in order to draw attention to its occurrence on the Australian mainland. This extension of its wide distribution from northern India throughout most parts of Malesia as well as Melanesia and Polynesia is not unexpected but not recorded in the literature. It is, however, not clear why a spectacular plant such as this has not been previously recorded from the vicinity of Darwin. If it was introduced, this could have occurred before European settlement as the tubers are eagerly eaten by the indigenous peoples throughout its distribution range (Engler, 1911). In Australian territory Bailey (1914) and Harmer (1976) reported this from Darnley Island and the vicinity of Darwin, respectively.

The latter identifies the species as *A. variabilis* Bl. seemingly a mis-identification by Specht (1958). It is possible that Bentham's prior record of *Brachyspatha variabilis* sensu Benth. (1878), non (Bl.) Schott from near Darwin prompted this identification, but his description of the inflorescence clearly indicated that the single specimen should be identified as *A. galbra* Bail. as Engler (1911) pointed out. The fact that Engler specifically mentioned that the specimen in question was unusual in several respects does not indicate that it should be transferred to an entirely different group of species.

Alternatively, the problem may be that the leaves of *A. campanulatus* are very

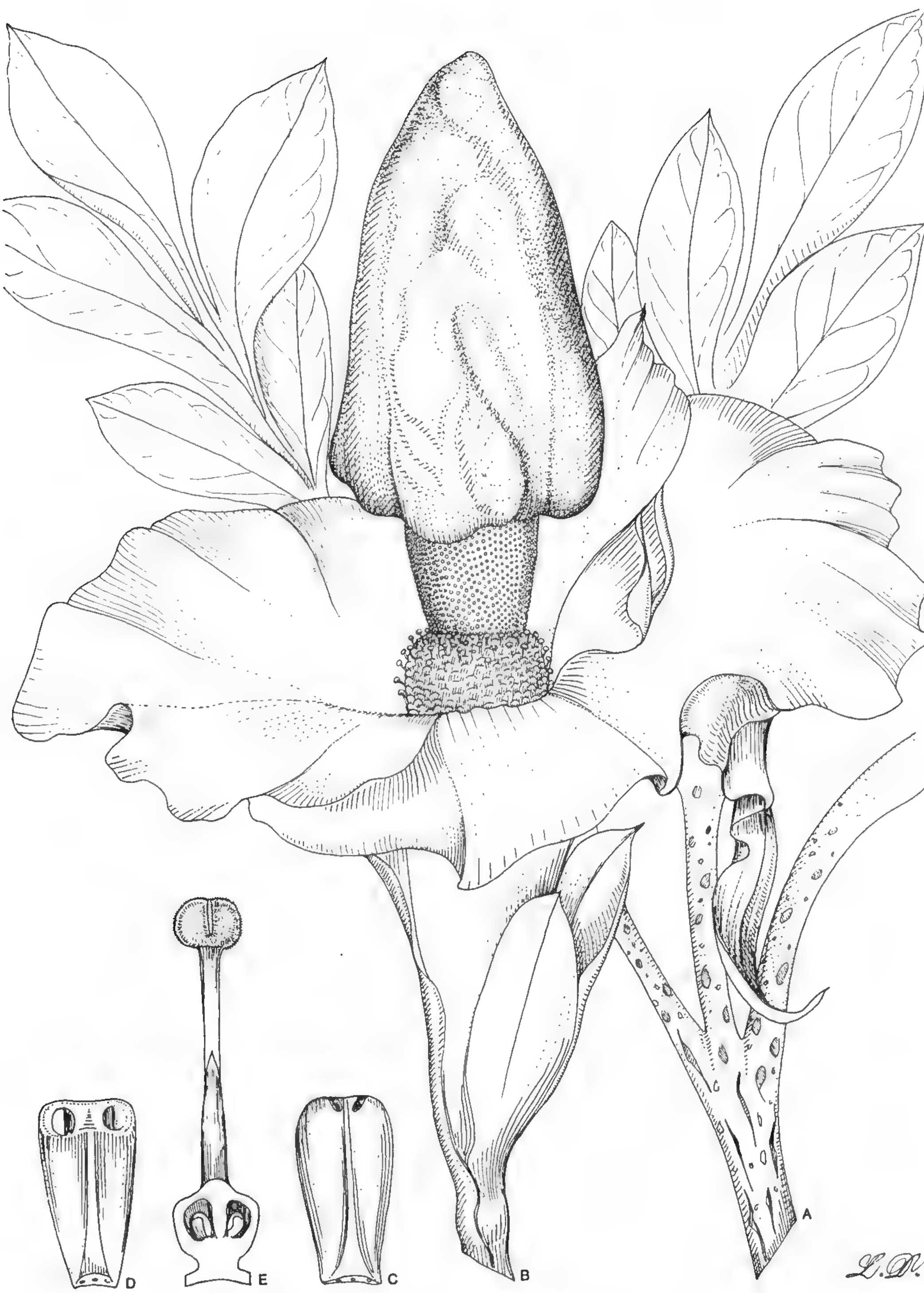


Fig. 1. *A. campanulatus*, A, part of compound leaf, x$^1/_2$; B, inflorescence, x$^1/_2$; C, anther in rear view, x10; D, anther in front view, x10; E, pistil with cut ovary, x5.

similar to those of *A. galbra* which is more common and in the literature often confused with *A. variabilis*, a species which does not occur in Australia. The difficulty with identification is aggravated by the fact that the leaves are produced at a stage when the diagnostic flowers of the plants are not available.

It is noteworthy that the plants figured by Baily (1914) from Darnley Island (SE of Daru, Papua New Guinea) have an abruptly tapering appendage which is much shorter than the rest of the spadix, while the appendages are comparatively longer and acutely conical on plants from near Darwin. The latter are described as being 20-25 cm long by Harmer (1976) but this could not be confirmed in specimens investigated. Throughout the entire range of the species appendage length varies much and as only few specimens are available it is difficult to comment on the significance of this variation. Judging by the variation in size of the various organs as indicated in the literature and, for instance, the wide range given by Backer & Bakhuizen van den Brink (1981) it seems as if those few specimens available were specifically selected to fit the size of herbarium sheets. Therefore, measurements of various parts of the plants are usually not indicated in the above description because it is considered that they might prove to be more confusing than helpful.

References

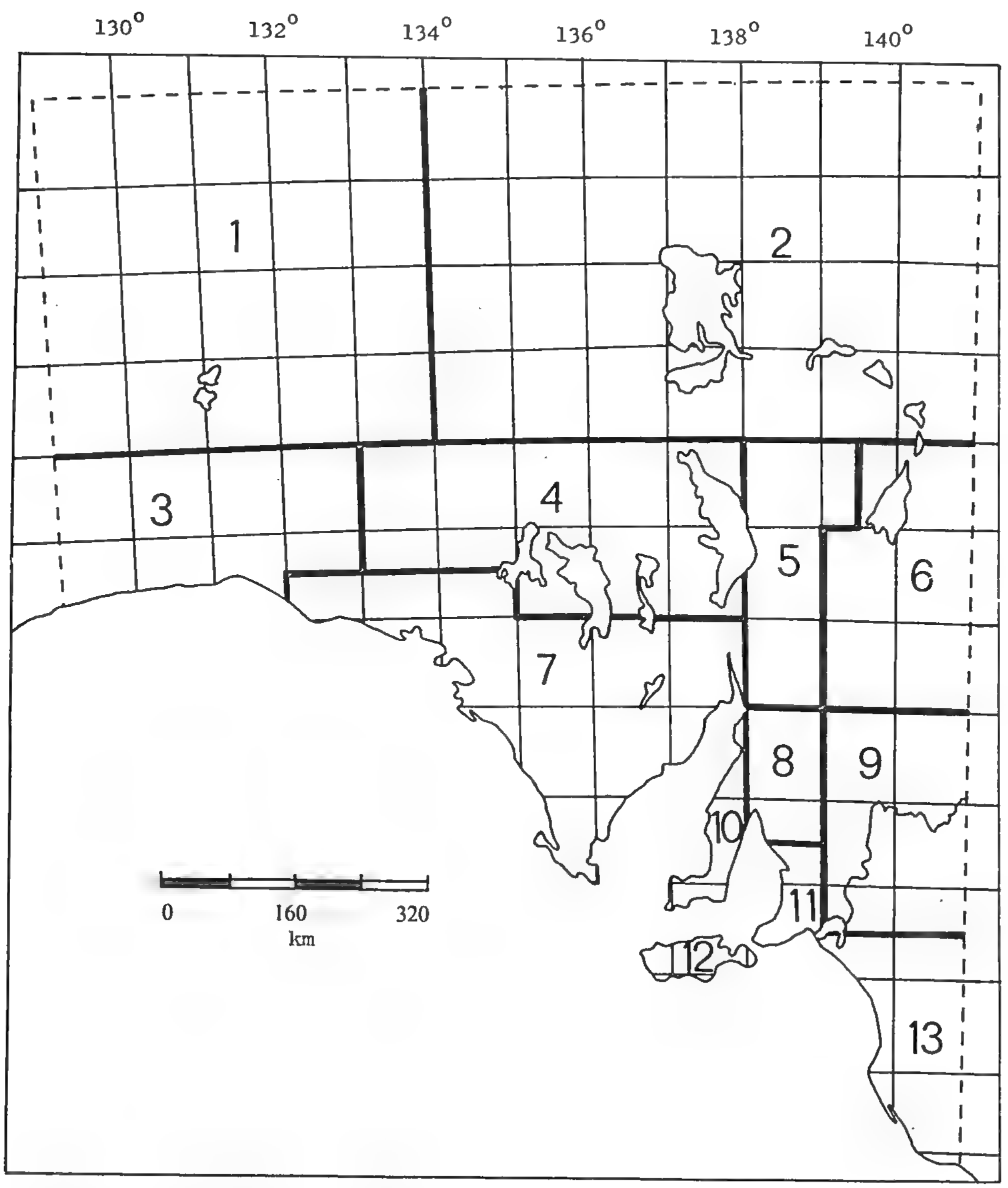
Backer, C.A. & Bakhuizen van den Brink, R.C. (jr) (1968). 'Flora of Java'. 3: 111. (Wolters-Noordhoff: Groningen).
Bailey, F.M. (1914). 'Contribution to the Flora of Queensland'. Qd. Agric. J. n. ser. 1, 124, t. 15, 16.
Bentham, G. (1878). 'Flora Australiensis'. 7: 154. (Reeve: London).
Engler, A. (1911). 'Pflanzenreich'. 23C: 76, 101 (Engelmann: Leipzig).
Harmer, J. (1976). 'North Australian Plants'. 1: 8 (Society for Growing Australian Plants).
Specht, R.L. (1958). 'Records of the American-Australian scientific Expedition to Arnhem Land'. 210. (Melbourne Univ. Press: Carlton, Victoria).

H.R. Toelken
State Herbarium of South Australia

Del. L. Dutkiewicz
State Herbarium of South Australia

REGIONS OF SOUTH AUSTRALIA ADOPTED BY THE STATE HERBARIUM — ADELAIDE

1. North-western
2. Lake Eyre Basin
3. Nullarbor
4. Gairdner-Torrens Basin
5. Flinders Ranges
6. Eastern
7. Eyre Peninsula
8. Northern Lofty
9. Murray
10. Yorke Peninsula
11. Southern Lofty
12. Kangaroo Island
13. South-eastern



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JOURNAL of the ADELAIDE BOTANIC GARDENS

CONTENTS

JOURNAL of the ADELAIDE BOTANIC GARDENS

Volume 6 Part 3

19 June, 1984

Instructions to Authors

Topics

Papers will be accepted in the following categories:

(a) Plant systematics (Australian and horticultural groups); (b) Descriptive plant morphology, anatomy and ecology; (c) Obituaries, biography and history; (d) Bibliographic studies, book reviews; (e) Botanical illustrations; (f) Noteworthy horticultural contributions.

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Manuscripts must be typed, with double spacing and margins at least 3 cm wide, on one side of the paper only. Three copies must be submitted. Captions must not be italicized, underlined or typed in capitals. All scientific names of generic or lower rank must be underlined.

The print area for illustrations is 18 x 13 cm (excluding captions). Half-tone material should be submitted this size if possible, but will be reduced by the printers, if necessary.

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The pattern of the paper should generally be:

(i) Title; (ii) Author and Address; (iii) Abstract (except for short papers); (iv) Introduction and subject matter; (v) Acknowledgements; (vii) References.

References

Text references to publications should be indicated as follows: (Smith, 1959), (Smith, 1959, p. 127), Smith (1959) or Smith (1959, pp. 125-208). The final section of the paper, headed 'References', should include only those titles referred to in this way. It should be laid out as follows:

Smith, L. L. (1879). The species of *Danthonia* found in pastures in Victoria. *Austral. J. Bot.* 65: 28-53.

Bentham, G. (1868). "Flora Australiensis", Vol. 4. (L. Reeve: London).

Baker, J.G. (1898). Liliaceae. In Thiselton-Dyer, W. T. (ed.). "Flora of Tropical Africa", Vol. 7. (L. Reeve: Ashford).

Journal abbreviations must be consistent within a paper and authors are recommended to follow "Botanico-Periodicum-Huntianum". Journals not cited in B-P-H should be abbreviated to conform with this general pattern. The following abbreviations for Australian states should be used: WA, NT, SA, Qld, NSW, ACT, Vic., Tas.

Text references to specimens should be italicized, for example *Kock 276*.

Indices

When required, follow the pattern on, for example, p. 106 of vol. 1, pt. 2.

Recommendations on taxonomic papers

Synonymy

Authors are requested to include in the synonymy only references to publications containing information additional to that to be published in the paper being submitted. Within this section journal and book titles must be conistently abbreviated. B-P-H journal abbreviations and book titles abbreviated in a similar way are desirable. Authors of references cited in the synonymy should preferably be abbreviated according to the 'Index of Author Abbreviations' compiled and published by Royal Botanic Gardens, Kew (1980). References may be cited as:

Benth., *Fl. Austral.* 4: 111 (1868) OR

Benth., *Fl. Austral.* 4: (1868) 111.

Citation of specimens

10-30 specimens should be cited for each species (or subspecific taxon), although this may be varied under certain circumstances. The author may decide whether or not to include dates of collections and the sequence, provided a constant pattern is adhered to throughout a paper.

Authors wishing to cite all specimens seen may list them all in an index to collectors after the style of the "Flora Malesiana" identification lists. Collections not identifiable by a collection number (assigned by either the collector or herbarium) should cite dates.

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A TAXONOMIC REVISION OF *PROSTANTHERA* LABILL. SECTION *KLANDERIA* (F.v. MUELL.) BENTH. (LABIATAE)

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Abstract

A taxonomic revision of *Prostanthera* section *Klanderia* is presented. General chapters on taxonomic history, morphology, pollination, and breeding systems precede the systematic treatment. Fifteen species are recognized of which eight are described for the first time. The new species are *P. florifera*, *P. incurvata*, *P. laricoides*, *P. monticola*, *P. patens*, *P. pedicellata*, *P. porcata* and *P. semiteres*. Two subspecies of *P. serpyllifolia* and two subspecies of *P. semiteres* are recognized. *P. semiteres* spp. *intricata* is described for the first time. Keys to the species and subspecies are provided. All recognized taxa are provided with full descriptions, distribution information (including maps), ecological and other relevant notes. All species are illustrated.

Morphological variation of *P. aspalathoides*, the *P. calycina-P. microphylla-P. serpyllifolia* complex, and the *P. laricoides* complex, plus the volatile leaf oil variation of *P. aspalathoides*, were investigated using the multivariate numerical techniques: canonical variate analysis, principal components and principal factor analyses, principal coordinates analysis, surface trend analysis (contour mapping) and differential systematics.

Patterns of variation appeared to be associated with environmental and historical factors in *P. aspalathoides* and in the *P. calycina-P. microphylla-P. serpyllifolia* complex. The distinctness of the Kangaroo Island populations appears to reflect the relatively long separation of this island from the mainland.

Contents

Introduction

Prostanthera species are evergreen sub-shrubs, shrubs or small trees (*P. lasianthos*) with decussate leaves, racemiform inflorescences, two-lobed calyces, four fertile two-celled anthers in each flower, terminal styles, and fruits composed of four mericarps. *Prostanthera*, with *Eichlerago*, *Hemiandra*, *Hemigenia*, *Microcorys*, *Westringia* and *Wrixonia* are grouped together in the subfamily Prostantheroideae of the Labiatae (Briquet 1895; Melchior 1964; Carrick 1976, 1977). Carrick (1977) offered a diagnosis for Prostantheroideae. His early paper (Carrick 1976) summarizes the key differences between all the genera in the subfamily (with the exception of *Eichlerago* which was not described at that time). The results from the work of Sharma & Singh (1982) on carpel morphology (refer pp. 219 & 220) require Carrick's diagnosis of the Prostantheroideae to be modified to:

> Stamens 4 or only 2 (adaxial or abaxial pair sterile); style terminal (may superficially appear subgynobasic); fruit of 4 separate mericarps or entire, dry and indehiscent (*Eichlerago*).

Comment on generic delimitations within the Prostantheroideae must await critical evaluation which is beyond the scope of this present study.

The Prostantheroideae are endemic to Australia with the most disjunct distribution being recorded by Jacobs & Pickard (1981) for *Westringia fruticosa* which they list as occurring on Lord Howe Island. Furthermore, this subfamily is the only one (of the Labiatae) in which any genus is endemic to Australia (Jessop 1980). The Prostantheroideae appear to be a distinct taxon of the Labiatae. This is indirectly verified by the fact that the Prostantheroideae, as circumscribed by Bentham [as 'Tribus VII. Prostanthereae.' (Bentham 1834, p. 447); and Bentham & Hooker 1876], has been maintained almost unaltered by subsequent authors. Cunningham recognized the homogeneity and distinctness of the group of genera which are now classified within this subfamily as early as 1825 (Cunningham, in Field 1825). However, prior to 1834 the genera which are now regarded as belonging to the Prostantheroideae were frequently placed in separate infra-familial groups (e.g. Reichenbach 1828; Bentham, in Lindley 1829-1830; Bartling 1830). Without evaluating the relationship between the subfamilies of the Labiatae, workers have

usually regarded the Prostantheroideae as most closely related to the Ajugoideae (e.g. Briquet 1895; Hillson 1959).

The Prostantheroideae, together with the Ajugoideae and Rosmarinoideae, are regarded as transitional subfamilies between the remaining Labiatae and Verbenaceae (Cronquist 1981). The relationship between these two families and the general affinities of the Lamiales are discussed by several authors (Cantino 1982; Carrick 1977; Cronquist 1981; Munir 1978 and Thorne 1976).

During preliminary non-numerical taxonomic and ecological studies of *Prostanthera* section *Klanderia*, several taxonomic problems were recognized. It was noted that certain taxa had patterns of character variation which appeared to be very complex. Furthermore, some of these taxa appeared to intergrade such that it was difficult to distinguish between them. The taxa which make up the complexes (*P. aspalathoides, P. calycina, P. serpyllifolia* and the *P. laricoides* complex [including synonyms—refer 'Systematic Treatment']) were subsequently examined in detail so that various biometrical analyses could be carried out in an attempt to simplify and visualize any underlying distribution pattern within these taxa. The results of the various analyses (refer 'Numerical Analysis') were used to suggest and to test hypotheses related to the relationship between the taxa. The information

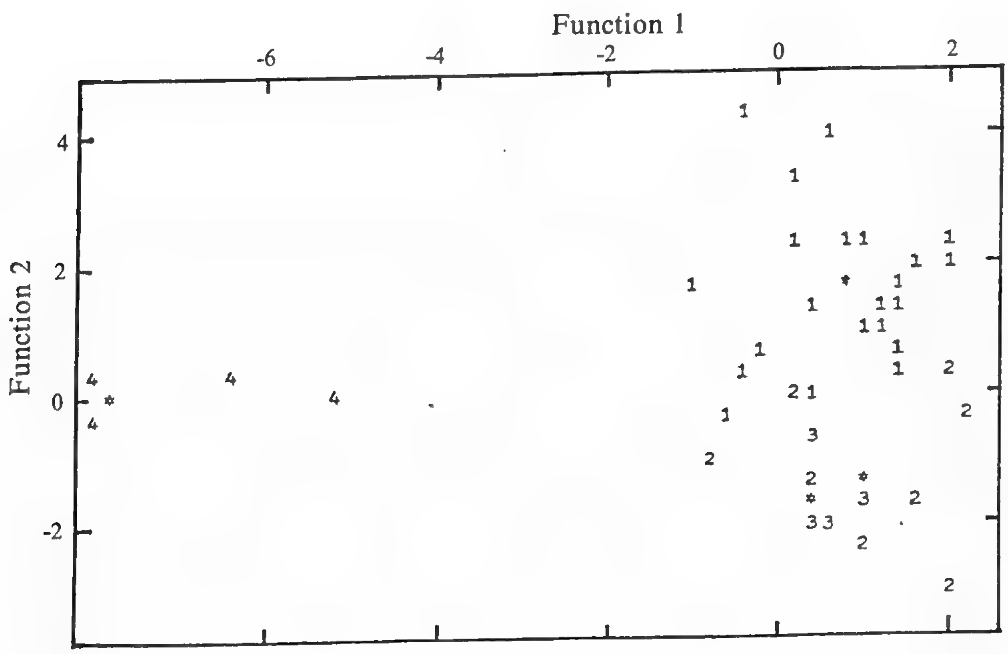


Fig. 1 Canonical variate scattergram (function 1 versus function 2) of the volatile leaf oils of *Prostanthera*. 1 = *Prostanthera* sect. *Prostanthera* series *Racemosae*; 2 = *Prostanthera* sect. *Prostanthera* series *Convexae*; 3 = *Prostanthera* sect. *Prostanthera* series *Subconcavae*; 4 = *Prostanthera* sect. *Klanderia*; * = group centroid.

provided then formed a basis for the construction of a taxonomic classification scheme. Other taxa could be evaluated and distinguished using non-numerical taxonomic procedures because they were significantly distinctive.

The geographic variation found in *P. calycina*, *P. serpyllifolia* and *P. laricoides* was studied using morphological features as taxonomic characters. In *P. aspalathoides* the geographic variation was studied using both morphological and volatile leaf oils (terpenoids) as taxonomic characters. The results of these analyses were used to test hypotheses related to the relationship between these taxa and environmental factors.

Without undertaking a critical evaluation of Bentham's infrageneric classification (refer 'Taxonomic History'), section *Klanderia* appears to represent a natural group. As pointed out by Bentham (1870), 'the shape of the corolla is so different from [that of section *Prostanthera*] . . . that this section might well be considered as a distinct genus . . .'. Other morphological characters (refer pp. 285-341) and, to some extent, its distribution (compared with that of sect. *Prostanthera*) support the distinctness of this section. A canonical variate scattergram (function 1 versus function 2) of the volatile leaf oils of 38 species is illustrated in figure 1. This canonical variate analysis was based on 64 specimens (50 from Lassak 1980, tables 4-6; 14 from personal collections). Within the limits of the data, a consideration of the volatile leaf oils also suggests that sect. *Klanderia* is distinct from sect. *Prostanthera.* Since sect. *Klanderia* appears to represent a distinct group within the genus, Bentham's sectional subdivision of *Prostanthera* is here accepted (Bentham 1870). A critical re-evaluation of Bentham's subdivision of sect.. *Prostanthera* is premature until the whole genus is revised. However, the canonical variate scattergram (Fig. 1) suggests that series *Racemosae* is distinct from the other two series, whereas series *Convexae* and series *Subconcavae* are less distinct from each other (at least on the first two functions).

Taxonomic History

Prostanthera was described in 1806 by Labillardière for *P. lasianthos*, a species from eastern Australia (Queensland, New South Wales, Victoria and Tasmania). Since then, a number of publications (e.g. Bentham 1834; Brown 1810; von Mueller 1868) have made significant contributions to our present understanding of *Prostanthera* Labill. However, the two most significant contributions on infrageneric concepts are those of Bentham (1870) and Briquet (1895).

While there has been general concensus on generic concepts, there has been less agreement on the subdivision of the genus. Bentham (1870) was the first to subdivide the genus into sections (sect. *Prostanthera* [as sect. '*Euprostanthera*'] and sect. *Klanderia*). These sections were largely based on floral characters (refer pp. 285, 286). He further subdivided section *Prostanthera* into three series (*viz.* series *Racemosae* [including the generic type, *P. lasianthos*], series *Convexae* and series *Subconcavae*). These series were based on the position of the inflorescence, the type of bracts, and the shape of the leaves (Bentham 1870, pp. 91 & 92).

Moore (1893) subdivided the genus into two sections (*viz.* section I [=sect. *Prostanthera*] and section II [=sect. *Klanderia*]). He further subdivided section I into two groups (*viz.* undersection I [=series *Racemosae* Benth.] and undersection II [=series *Convexae* Benth. and series *Subconcavae* Benth.]).

Briquet (1895) subdivided the genus into three sections (*viz.* sect. *Depremesnilia* [as sect. '*Depresmenilia*'—typographical error], sect. *Cryphia* [=sect. *Klanderia*], and sect. *Prostanthera* [as sect. '*Euprostanthera*']). *Prostanthera chrysocalyx* (F. v. Muell.) Briq. [= *Depremesnilia chrysocalyx* F. v. Muell., type species of sect. *Depremesnilia* (F. v. Muell.) Briq.] was transferred to *Pityrodia chrysocalyx* (F. v. Muell.) Gardner (Chloanthaceae) by Gardner (1931). For futher details refer Munir (1978, 1979).

Bentham chose von Mueller's generic name *Klanderia* as a sectional name, over the earlier name *Cryphia* (of R. Brown), because the latter name was derived 'from a character probably abnormal in the particular flower examined' (Bentham 1870, p. 105). Briquet (1895) chose *Cryphia* as the sectional name, presumably because it is the earlier generic name. However, since generic names do not have priority outside their own rank (Stafleu *et al.* 1978: Art. 60), Bentham's sectional name must be followed.

Briquet (1895) accepted Bentham's (1870) subdivision of sect. *Prostanthera* into series.

In 1970 Carrick began a revision of the genus. Only two publications (Carrick 1976, 1977) on related genera were completed before his death in 1978. He published a key to the recognized species of *Prostanthera* in Althofer (1978) and his contribution to the more formal taxonomic aspects of this book appears to be considerable. Unfortunately, he apparently had not finalized his concept of the genus. There is no manuscript and his occasional brief notes are insufficient to formulate any appreciation of his concepts in *Prostanthera.*

Approximately eighty species have been described, all from Australia. Nelson (1981) listed 60 previously described species of *Prostanthera* which were recognized by Carrick. However, he incorrectly cited the number of species for Tasmania as 19 (with 17 endemics). Carrick (Barker, *in litt.*) actually recognized 3 species (with no endemics) for Tasmania. In addition to those listed in Nelson (1981), Carrick (Barker, *in litt.*) recognized 37 species for New South Wales (of which 19 are endemic) and 10 species for Queensland (of which 6 are endemic).

Methods, materials and presentation

The measurements of the morphological characters (for both numerical and non-numerical analyses) and the descriptions of all taxa were made from herbarium specimens. 605 specimens (Conn 1982, pp. 258-264) were used in the various biometrical analyses. Some of these specimens were replicate samples from the same individual whereas others were replicate samples from local populations. The quantitative and qualitative values of the various characters (for each individual) as used for the numerical analyses, are the average of five separate observations. Although Blackburn (1980) pointed out the inadequacy of using mean character values as a measure of resemblance, particularly when character states overlap considerably between taxa, his method was not used because his data standardization procedure requires quantitative data to be grouped into a fixed number of class intervals (usually 8). Furthermore, the necessity to set class boundaries is regarded as inappropriate.

The descriptions were supplemented by personal field observations. In the descriptions, those character states which occur in one or a few specimens (hence, occur in fewer than 10% of the individuals in the relevant taxon) are enclosed by parentheses. Parentheses are also used to enclose rarely occurring character states which may be present in an otherwise typical individual specimen. No distinction is made between these two situations.

In general, usage of terms follows Lawrence (1955), Porter *et al.* (1973), and Stearn (1973). Terminology for plane shapes follows Ball *et al.* (1962). Author and literature abbreviations follow Stafleu & Cowan (1976, 1979, 1981). English nomenclature for Australian birds follow Schodde *et al.* (1978). I found that it was only necessary to recognize formally one level of variation within any single species. Therefore the proposal of Raven *et al.* (in Raven 1974) and the example of *Flora Europaea* (refer Tutin *et al.* 1964) to use 'subspecies' as the only infraspecific category was followed in this treatment.

Although I began my revision of *Prostanthera* in 1979, most of the herbarium material of this genus had been on loan to the State Herbarium of South Australia (AD) since 1972/73. Collections on loan from the British Museum (BM) were returned, upon request,

before many taxa were fully considered. In a number of cases this has prevented typification. I was reluctant to endanger the material further by requesting an additional loan of the relevant collections so soon after their return.

The distribution of each taxon is briefly summarized after its description. The distribution summary and the selected citation of specimens examined are grouped according to various regional subdivisions. The regional subdivisions that I have used for the States are: for Queensland I have followed the pastoral divisions used by the Queensland Herbarium (BRI) [as in *Contr. Queensl. Herb.* 19 (1975) back end paper], for New South Wales those of Jacobs & Pickard (1981) (which is modified from Anderson 1961), for Victoria those of Cochrane *et al.* (1968), for South Australia those of Laut *et al.* (1977a, 1977b, 1977c, 1977d), and for Western Australia those of Beard (1980).

The conservation status of each taxon is provided (as stated by [Conn in] Leigh *et al.*, 1981 or using the formulae of Leigh *et al.*, 1981).

The ecological notes are taken from collector's notes on the labels of herbarium sheets, supplemented in most cases by personal field observations.

Common names are included where known.

Herbarium abbreviations are those given in Holmgren *et al.* (1981). Since Kings Park and Botanic Gardens (West Perth, Western Australia) is not listed in 'Index Herbariorum', collections examined from this herbarium are referred to as 'KP'. Collections from the following herbaria were examined: A, AD, ADW, BM, BR, BRI, C, CANB, CBG, E, F, GH, GOET, HAL, HBG, HO, K, KP, L, LD, LE, LY, M, MEL, MO, NE, NSW, NT, NY, P, PERTH, S, SYD, UC, UP, US, W, WRSL, WU.

Herbarium material was studied at the State Herbarium of South Australia (AD), numerical analyses were carried out in the Botany Department of the University of Adelaide, and preliminary gas-liquid chromatographic analyses were carried out in the Organic Chemistry Department (University of Adelaide). The detailed gas-liquid chromatographic analysis of the volatile leaf oils of *P. aspalathoides* (as presented in this study), was carried out at the Biological and Chemical Research Institute, Rydalmere (N.S.W.).

Selected morphological characters

In this chapter a detailed discussion of various morphological structures, including the extent of morphological variation in sect. *Klanderia* is provided. Those characters which have been employed in the taxonomy of the group or those which are of potential taxonomic value are given particular emphasis. The definitions of terms which are used later in this revision are also provided.

Habit

All axes of the sub-shrubs or shrubs of *Prostanthera* sect. *Klanderia* have continuously active meristems. The plants are architecturally differentiated into a primary axis ('stem') and equivalent branches. Branching appears to occur more or less continuously. This shoot construction is referrable to Attim's architectural model (Hallé *et al.* 1978). Periodicity of growth appears to be induced by seasonality and apparently is not endogenous.

The primary axis is frequently damaged. In such instances, adjacent lateral axes may 'replace' the primary one. If the primary axis of young plants is damaged, it may be very short, such that the usually many-branched, mostly erect small shrub appears to be multi-stemmed. The lower branches usually develop at or just above ground level. Some species form densely branched compact shrubs (a common habit form of *P aspalathoides*),

whereas others have fewer branches and an open habit (e.g. *P. chlorantha* and *P. patens*). *P. walteri* has a habit of tangled branches, especially in exposed situations. Semi-prostrate to prostrate forms are found in coastal forms of *P. serpyllifolia* (e.g. at Innes National Park and Cape Cassini, South Australia), and in the subalpine species *P. walteri* and *P. monticola*. The habit is modified by salt-pruning in *P. serpyllifolia*, but in the latter two species it is caused by extremely low temperatures associated with the ice and snow. In more sheltered situations, these three species have the more typical semi-erect to erect habit.

In *P. chlorantha* shoots occasionally arise (*Conn 685*) from horizontal stems that are either on or just below the soil surface.

Indumentum

Both glandular and non-glandular trichomes are present. Non-glandular trichomes are here referred to as 'hairs' (refer descriptions in 'Systematic Treatment'), whereas glandular trichomes are referred to as 'glands'. Therefore, the various parts of a plant are described as glabrous or hairy (with reference to the non-glandular trichomes), irrespective of the presence or absence of glands.

The glandular trichomes ('glands') are more or less hemispherical (typical of those in many members of the Labiatae, *cf.* Uphof 1962, Fig. 55) and are particularly common on the distal parts of branches, on the outer surface of the calyx, and on the pedicel.

The non-glandular trichomes ('hairs') occur on most parts of the plants. *P. pedicellata* and *P. semiteres* have glabrous branches and leaves. However, all other species have some hairs on the vegetative parts. The hairs of the branches are frequently denser along two narrow zones (each on opposite 'sides' of the branches which extend from the leaf axil region to the next more distal nodal region between the opposite leaf bases). The hairs tend to be denser on the distal (juvenile) portions of the branches. The hair density of the branches, as recorded in the descriptions, was measured from the second to fifth distal internodes.

The leaves are usually more densely hairy on the abaxial surface than adaxially. Frequently the hairs are restricted to the midrib region of the abaxial surface and/or to the base of the leaf.

The pedicel, margin of prophylls, and the outer surface of the calyx and corolla (particularly on the respective lobes), are frequently hairy. The inner surface of the calyx is glabrous in most species. However, *P. incurvata*, *P. laricoides*, *P. patens*, *P. pedicellata* (usually), and *P. semiteres* (in this study all of these species are referred to as part of the *P. laricoides* complex of Western Australia) are hairy on the inner surface of the calyx. Sometimes these hairs are restricted to the distal positions of the calyx lobes.

The indumentum is usually more or less tomentose, sometimes becoming pilose. The hairs are more or less patent basally and recurved to reflexed distally, such that the hairs often appear curled. The hairs of *P. calycina* are appressed and are not curled. Furthermore, they are relatively long (up to 0.5 mm long) and stiff. Most species have simple one-celled hairs, however *P. chlorantha* (Fig. 54) and the Kangaroo Island populations of *P. serpyllifolia* ssp. *microphylla* have irregularly branched, multi-celled hairs similar to those of *Lavandula officinalis* (Hummel & Staesche 1962, Fig. 8).

The density of hairs, particularly on the branches, is in general extremely variable and of little taxonomic value (e.g. refer *P. semiteres*, p. 112). The juvenile portions of the branches are usually relatively densely hairy. These hairs tend to be lost from the older branches. If plants were collected during growth-limiting conditions the amount of new growth would be very small and so, a low hair density would be recorded.

Therefore, the density of hairs (on branches), as recorded in this study, may indirectly reflect the seasonal climatic conditions prior to the time of collection.

Leaves

The leaves of all species are decussate. They are more or less terete (often slightly compressed) in *P. aspalathoides*, *P. florifera*, *P. incurvata*, *P. laricoides*, *P. pedicellata*, and *P. semiteres*. All of these species have leaves which are narrow and more or less oblong to obovate (for details refer relevant species description in 'Systematic Treatment'). The petiole of these species is very short or absent. All remaining species usually have distinct, but often short-petiolate leaves. Ovate to suborbicular leaves are found in *P. chlorantha*, *P. patens*, *P. serpyllifolia* ssp. *microphylla*, and occasionally in *P. ringens*. Normally, the leaves of *P. ringens* and *P. serpyllifolia* ssp. *serpyllifolia* are more or less flat and oblong to obovate. *P. monticola*, *P. porcata* and *P. walteri* have the largest leaves (for the section) which are relatively broad. *P. grylloana* has spathulate conduplicate leaves.

The leaf margin is frequently recurved, except for those species with more or less terete leaves. In many instances the recurvature of the margin is, at least in part, a response to water stress and so, is probably of dubious taxonomic value. The leaves of *P. grylloana* appear to respond to water stress by becoming strongly conduplicate, thus reducing the exposed adaxial surface area of the leaf.

The lamina shape, size, and other features (as discussed above), are frequently useful supplementary characters, particularly for verifying initial determinations.

Inflorescence

Carrick (in Althofer 1978) and all previous workers have regarded the inflorescence of section *Klanderia* as lateral (axillary), with each inflorescence being a single flower. A detailed re-evaluation of the structure of the inflorescence is not possible until all genera in the subfamily Prostantheroideae have been examined. However, it is possible to give brief tentative interpretations of the inflorescence structure for the genus.

Architecturally, the inflorescence of the species in section *Klanderia* is pleonanthic (*sensu* Hallé *et al.* 1978) since flowering usually coincides with shoot expansion. All floral [=flower-producing] axes end in non-floral buds [hence ≃ indeterminate] (Fig. 2). Briggs and Johnson (1979) regard this structural type as blastotelic [≃ polytelic, Troll 1964 & 1969] and since the R_Z axes (refer Fig. 2) continue to grow beyond the flowering region, they are auxotelic.

Since the prophylls (Fig. 2B) are closely associated with the developmental sequence of the flower, the ultimate 'internode' is thought to represent the last infrafloral region. In the Myrtaceae Schmid (1972, Fig. 24) and Briggs and Johnson (1979) have frequently found that the transition from the base of the flower to the anthopodium is externally very indistinct. Therefore, Schmid (1972) regards the axis distal to the prophylls as the basal part of the flower which is also anatomically indistinguishable from the primary axis (a_1 axis, Briggs & Johnson; pedicel, Schmid), except where the vascular traces diverge to the prophylls. Contrary to this, Briggs and Johnson (1979) regard the anthopodium as an internode of the axis below the flower. The validity of distinguishing the ultimate and penultimate flower-bearing axes requires further evaluation. The applicability of such a distinction in *Prostanthera* is not known at this stage. However, it is of interest to note that Tölken found a developmental differentiation between the two 'internodes' in *Crassula* (Toelken [Tölken] 1981). The anthopodium ('pedicel', Toelken 1982) of *Crassula pedicellosa* elongates as the fruit matures, but the a_1 axis ('peduncle', Toelken 1982) does not elongate. In section *Klanderia* it appears to be the a_1 axis (if any) which elongates as the fruit matures, not the anthopodium. In the 'Systematic Treatment' pedicel is regarded as the a_1 axis plus the anthopodium.

Two ways of interpreting the inflorescence structure of *Prostanthera* are discussed below.

One interpretation of the inflorescence of the species in section *Klanderia* is presented in figure 2. Here the uniflorescences (Briggs & Johnson 1979) [unit inflorescences, Johnson & Briggs 1975, Johnson 1976; ≃ partial inflorescences, partial florescences, Troll 1964 & 1969, Weberling 1965, 1981, 1982] are regarded as monadic and the resulting conflorescence [= synflorescence, Troll 1964 & 1969] is racemiform on leafy branches (Fig. 2).

In section *Prostanthera* similar frondose racemiform conflorescences (with monadic uniflorescences) are found in *P. caerulea*, *P. cuneata*, *P. eckersleyana*, *P. spinosa* and *P. teretifolia*. *P. rotundifolia* and *P. stricta* (both sect. *Prostanthera*) have a bracteose blastotelic racemiform conflorescence (with monadic uniflorescences) on anauxotelic Rz axes (Fig. 3a), since the axis is terminated by an aborted vegetative bud. In *P. lasianthos* (Figs 3b & 4) and *P. ovalifolia* the racemiform conflorescences are arranged into a super-conflorescence (*sensu* Briggs & Johnson 1979).

Troll (1964) and Weberling (1965, 1981) concluded that all of the labiate genera which they had studied, have polytelic synflorescences with "cymose 'partial inflorescences'" (Weberling 1965) [= cymose uniflorescences, Briggs & Johnson 1979]. For examples of cymose inflorescences of several labiates refer Troll (1964, Figs 62-68). In *Prostanthera* the monadic uniflorescences can be regarded as derived from the cymose condition by reduction because the primary (penultimate) axis (a_1 axis, Briggs & Johnson 1979] is uninodate with a pair of prophylls [Vorblätter, Troll 1964, 1969] occurring at this distal node (Fig. 2). Furthermore, the ultimate 'internode' [anthopodium, Briggs & Johnson

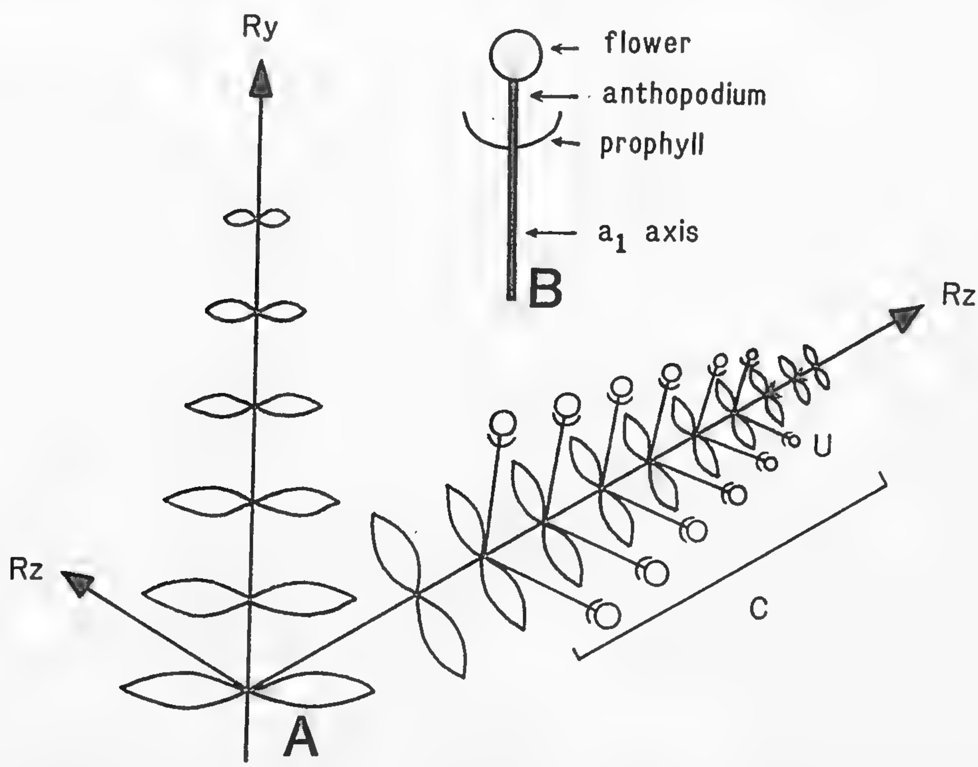


Fig. 2. Diagrams of a typical flowering branch of *Prostanthera* sect. *Klanderia*. A. general diagram; B. detail of uniflorescence. C = conflorescence; Ry = the branch from which the Rz axis arises; Rz = the branch from which the a_1 axis arises; U = uniflorescence.

1979] is terminated by a flower (Fig. 2). Frondose racemiform conflorescences typical of those found in section *Klanderia* are also found in *Westringia* (except *W. cephalantha* which has a bracteose conflorescence similar to *P. rotundifolia*). Other examples of labiates with monadic uniflorescences are *Salvia patens* (Troll 1964, Fig. 7311) and *Teucrium fruticans*.

This interpretation assumes that the labiates have a basically cymose inflorescence structure. It then follows that the single flowers have to be interpreted as uniflorescences which are aggregated into conflorescences.

A second interpretation is that the basic inflorescence should be regarded as a botryum (Figs 2 & 3a), with elaboration to form a dibotryum (Fig. 3b) or pleiobotryum [actually a tribotryum] (Fig. 4). From this it follows that the presumed 'cymose' condition found in many herbaceous labiates (e.g. *Salvia*) has resulted from modifications of the basic botryine condition.

Of the two interpretations I prefer the former. However the former one does not support the presumed phylogeny of the Labiatae subfamilies as proposed by Hillson (1959). He proposed that the Ajugoideae and Prostantheroideae are primitive relative to the other subfamilies, with the Stachydoideae as the most advanced. Since the former interpretation regards the Prostantheroideae inflorescence as derived, this subfamily is more advanced, at least on this character, than those groups which primarily have a

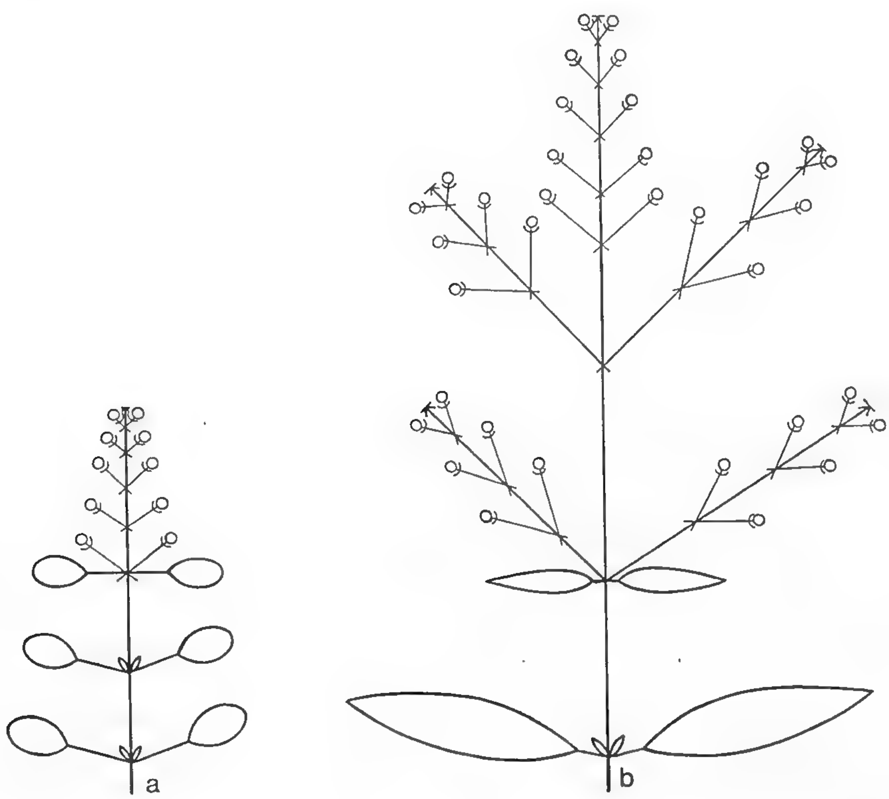


Fig. 3. Diagrams of typical inflorescences of *Prostanthera* sect. *Prostanthera*. a. Flowering branch of *P. rotundifolia* (Live material, Royal Botanic Gardens, Melbourne); b. Flowering branch of *P. lasianthos* (*Ashby 4454*, AD).

cymose condition. The latter interpretation regards the botryine condition as primitive and the 'cymose' condition as advanced. From this one can more readily support Hillson's (1959) opinion that the Prostantheroideae is one of the more primitive subfamilies.

Whether inflorescence structure reflects phylogenetic relationship is not clear without further detailed studies. Hillson (1959) concluded that other macromorphological features were not reliable indicators of phylogeny within the Labiate. Likewise, inflorescence structure may prove unsuitable.

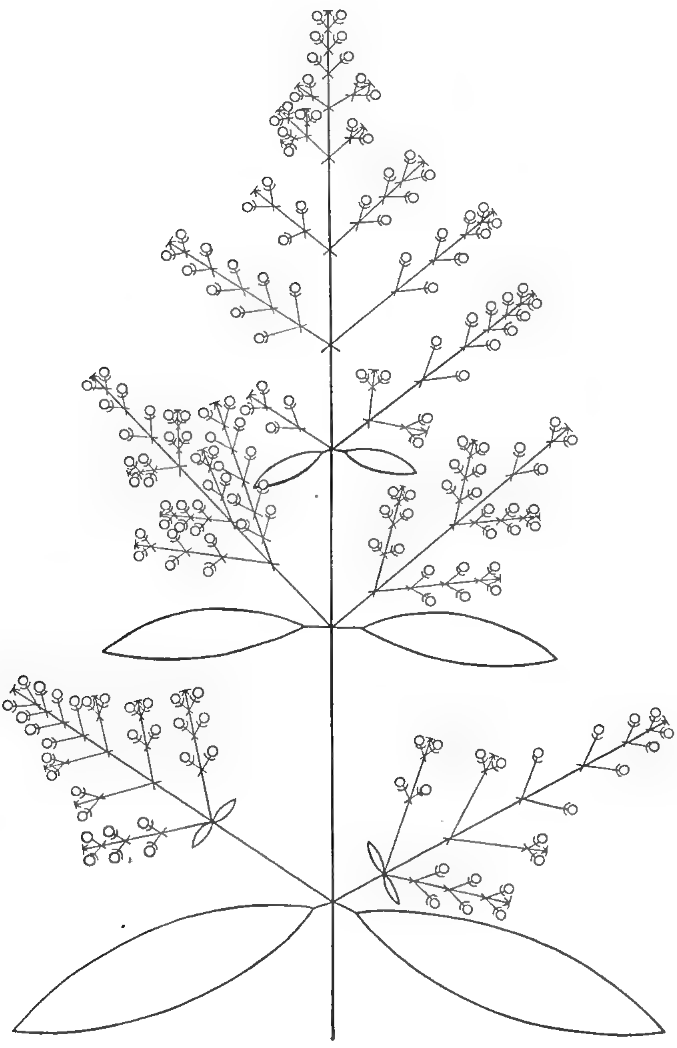


Fig. 4. Diagram of inflorescence of *Prostanthera lasianthos*. (*Ashby 5304*, AD).

Prophylls ('bracteoles')

In sect. *Klanderia* the prophylls usually occur near or at the base of the calyx (hence, anthopodium reduced). The anthopodium is relatively long in *P. patens* and *P. ringens*, and is of some taxonomic value for distinguishing them from the remaining species of this section. The prophylls are soon deciduous in *P. patens*. They are usually narrow, more or less ovate to obovate in most species. Those of *P. patens* are narrower than for the other taxa.

The prophylls are usually opposite, but in *P. chlorantha* they are occasionally displaced vertically relative to each other, such that they appear to be alternate.

Calyx

The calyx varies from 4 to 15 mm long. *P. calycina*, *P. chlorantha*, *P. monticola*, and *P. walteri* have calyces which are at least 8 mm long. The other species usually have smaller calyces. The calyx is 2-lobed, with the more or less triangular lobes being approximately equal in length (Fig. 53).

Since the calyx frequently enlarges as the fruit matures, the description of the calyx, including all measurements, is based on flowering material. In fruiting material the calyx lobes remain more or less porrect (Fig. 53) unlike those in section *Prostanthera*, where the abaxial lobes incurves to cover the fruit (Fig. 52).

The calyx varies from green to maroon. Certain species appear to have only one colour (e.g. *P. florifera* has only maroon calyces), whereas other taxa (e.g. *P. serpyllifolia* ssp. *microphylla*) have populations which show the full colour range. The taxonomic significance of the colour variation is not known, but is thought to be of little importance.

Corolla

The corolla tube is slightly incurved and varies from 9 to 17 mm long. In cross-section it is more or less elliptic, frequently elliptic-ovate. The throat and mouth are slightly expanded so that the maximum width at the mouth (along shortest axis) is approximately 5 mm. [The shortest axis of the mouth is more or less equivalent to the distance between the bases of the two lateral lobes.]

The corolla is normally described as being bilabiate (2-lipped) (e.g. Bentham 1870; also refer recent flora accounts). However, the position of the two lateral lobes is such that it is frequently difficult to decide (using macromorphological features) to which lip they belong (e.g. *cf.* Figs 53C, 70B & 73C). To avoid possible confusion, the corolla is described as being 5-lobed; comprising two adaxial, two lateral, and one abaxial. The two adaxial lobes are more or less completely fused and are referred to, collectively, as the adaxial median lobe-pair (Fig. 53, also refer species descriptions).

The anthers, style and stigma tend to lie next to the adaxial part of the inner surface of the corolla tube. Therefore, the lobes which are an extension of this adaxial surface are the adaxial median lobe-pair. Since the pedicel (a_1 axis + anthopodium) frequently twists through at least ninety degrees, the position of the anthers, style and stigma can be used to avoid orientation problems when attempting to locate the adaxial lobe-pair. This terminology also avoids the possible confusion arising from the application of the terms upper and lower lips.

All lobes (except the adaxial lobe-pair, which is more or less porrect) become more recurved or more strongly reflexed once the anthers have fully dehisced.

The species of section *Klanderia* have corollas which are usually red, often green, and occasionally yellow. Many species, e.g. *P. aspalathoides*, show the full colour range, whereas others, e.g. *P. chlorantha*, *P. ringens*, *P. monticola* and *P. walteri* have more or

less green corollas only. It was found that when the corolla is placed in 100% ethyl alcohol, all colour forms turned red (sometimes very faintly). In contrast, the corollas of the species (23 species tested) of section *Prostanthera* almost invariably turned blue when placed in 100% ethyl alcohol, irrespective of original colour. The only exception was that species with white corollas (of sect. *Prostanthera*) became translucent to transparent. Therefore, flowers of species from section *Klanderia* have red corolla pigments which may be masked by other pigments. The corollas of species in section *Prostanthera* usually contain blue pigments with colour variation being the result of masking by additional pigments or by the possible lack of pigmentation.

The inner surface of the corolla (in sect. *Klanderia*) is usually paler than the outer surface. Frequently, the inner surface has a yellow or cream-coloured tinge (e.g. in *P. florifera*, *P. aspalathoides*). Dark, more or less maroon dots or streaks are frequently present on the distal part of the inner surface of the tube, the mouth and the abaxial median lobe.

Androecium

The flowers are protandrous (typical of most Labiatae, van der Pijl 1972), with 4 epipetalous stamens located between the abaxial and lateral lobes, and between the adaxial lobe-pair and the lateral lobes. They are inserted approximately 8 to 10 mm above the base of the corolla. The stamens are didynamous, with the two abaxial ('lower') ones longer than the two adaxial ('upper') ones.

The filaments are more or less ligulate and 5 to 8 mm long, They are basally curved towards the adaxial surface of the corolla and then extended forward, lying next to the inner adaxial surface of the corolla. The filaments are glabrous, but triangular glandular trichomes are frequently present.

The basifixed anthers are tetrasporangiate and bilocular (*sensu* Green 1980). The basal lobes of the anthers are obtuse or shortly acuminate. Triangular trichomes are frequently present on these lobes. In *P. florifera*, *P. grylloana*, *P. laricoides*, *P. patens* and *P serpyllifolia* ssp. *microphylla*, the connective is extended to form a short appendage. In *P. aspalathoides* and *P. chlorantha*, the appendage is usually minute (mostly less than 0.3 mm long) and so, frequently appears absent. The appendage usually has a few triangular trichomes, particularly at or near the apex. The anthers are mostly obtuse to slightly emarginate apically. Dehiscence is introrse by longitudinal slits. Further details on how dehiscence is actually affected is discussed in the chapter on Pollination.

The anthers are held within the corolla, just short of the apex of the adaxial lobe-pair, and in effect are not exserted, or if so then only partially. The two abaxial anthers are distal to the adaxial pair (Fig. 53). Laterally, one abaxial and one adaxial anther are juxtaposed (Fig. 53B). The two abaxial anthers are positioned such that the ventral surfaces (dehiscence zone) of each are in contact (Figs 53 & 56F). The adaxial pair is similarly arranged. The stomium of each anther remains in contact with its opposite equivalent until dehiscence is completed. The distal abaxial pair matures first and usually completes dehiscence before the adaxial pair. Once dehiscence is completed the stamens separate and relocate (separately) next to the inner surface of the abaxial parts of the corolla tube. This is illustrated in figure 52A-C, for section *Prostanthera*. At this stage, the anthers are often exserted between the lateral and abaxial corolla lobes.

Disc and Gynoecium

The more or less cylindrical disc is usually 0.5 to 1 mm long. The 2-carpellate gynoecium, which is distal to the disc, is superior, glabrous, and 20 to 30 mm long. The 2 locules of the ovary are further divided by a false septum, so that the ovary appears to be 4-loculate (Briquet 1895; Cronquist 1968, 1981; Sharma & Singh 1982).

The ovary is 4-lobed and, although the style is frequently regarded as gynobasic (e.g. Beadle *et al.* 1976; Haegi 1981; for further references refer Carrick 1977, p. 119), it is terminal (Junell 1934; Hutchinson 1969; Hickey & King 1981; Cronquist 1981). This arrangement is found in the Prostantheroideae and in *Ajuga* (Ajugoideae) (following system of Briquet 1895). All other subfamilies of the Labiatae are usually regarded as having the typical gynobasic style (refer Briquet 1895; Junell 1934; Weberling 1981). However, Sharma & Singh (1982) have shown that although the style appears to be gynobasic in the Labiatae, it is the rapid growth of the four ovary lobes which result in the style becoming deeply sunken in between these lobes. The distal lobing of the ovary is often obscure, especially when the ovules abort. Although the placentae appear axile, Sharma & Singh (1982) have shown that the Labiatae have a 'placentation which is neither true axile nor true parietal, but [is] an intermediate condition between the two'. The septum development is typical of that found in flowers with axile placentation, except that the two placental ridges arise from the inner lateral walls of the ovary (at the fused margin of the two carpels), which is typical of parietal placentation. The ovules are anatropous, laterally to sub-basally attached on their ventral surface, two per carpel (appearing solitary because of false-septum), unitegmic and tenuinucellate (which is characteristic of the Labiatae, refer Corner 1976; Sharma & Singh 1982). The stigma is shortly bifid distally.

The various features of the gynoecium appear to be of no taxonomic importance since they are relatively invariable throughout section *Klanderia*.

Fruit and Seeds

The schizocarpic fruit is heteromericarpous (Roth 1977), comprising 4 (1-seeded) mericarps [nutlets] (Figs 64E, 71E, 75E). Winkler (1939, 1940) regards the fruits of the Labiatae as foraminose (perforated by large hole) capsules since the mericarp ('Klausen') correspond to parts of the capsule wall which separates from the remaining carpel parts by a ring-shaped cleft. This type of separation involves tissue of the median part of the capsule—one of Stopp's (1950a, 1950b) three types of foraminose capsule types. As the seeds develop, the distal lobes of the fruit (formerly those of the ovary) enlarge. The seeds are enclosed in pericarp and the seed coat is reduced to the outer integument. As pointed out by Corner (1976), the seed-coat has little structure and so is 'almost negligible'. The endosperm is cellular and oily.

A comprehensive anatomical study of the fruits of the Labiatae was carried out by Wagner (1914; as summarized by Roth 1977). He found that the structural features of the pericarp were of taxonomic use in distinguishing certain genera of the Labiatae. Wojciechowska (1958, 1961a, 1961b, 1966) used morphological and anatomical features, particularly of the sclerenchymatous layer of the pericarp, to distinguish between the fruits of a number of European Labiatae genera. Within section *Klanderia*, macromorphological features of the fruits and seeds appear to be of little taxonomic value because they are relatively invariable.

Pollination and floral biology

Introduction

Proctor & Yeo (1973) and, in particular, Faegri & van der Pijl (1979) provide brief reviews of the literature which discusses pollination in the Labiatae. The various concepts (e.g. pollination syndromes and blossom types) are mostly based on northern hemisphere species. Neither book mentions *Prostanthera* or the other genera of the Prostantheroideae. The only publication on pollination in the Prostantheroideae was by Keighery (in Armstrong *et al.* 1982) (refer p. 222). Since very little information has been published on

the breeding systems, pollination mechanisms and pollinators of *Prostanthera*, our understanding is incomplete. The extent of our knowledge, which is mostly very superficial, is summarized in this chapter.

Field observations

I have observed the Crescent Honeyeater (*Phylidonyris pyrrhoptera*) visiting flowers of *P. walteri* (sect. *Klanderia*) and unidentified honeyeaters visiting *P. florifera* and *P. monticola* (both sect. *Klanderia*). Keighery (1980) recorded three bird pollinated *Prostanthera* species from the South West Botanical Province (Beard 1980) of Western Australia. However, the method used for determining actual pollination from mere visitation is not given. He (Keighery, *in litt.*) has recorded White-fronted Honeyeaters (*Phylidonyris albifrons*), Brown Honeyeaters (*Lichmera indistincta*) and White-eared Honeyeaters (*Lichenostomus leucotis*) visiting *P. aspalathoides* [the locality suggests that this species is *P. incurvata*], *P. grylloana* and *P. microphylla* (= *P. serpyllifolia* ssp. *microphylla*); Singing Honeyeaters (*Linchenostomus virescens*) visiting the first two *Prostanthera* species; Purple-gaped Honeyeaters (*Lichenostomus cratitius*) visiting *P. grylloana*; and Western Spinebills (*Acanthorhynchus superciliosus*), Tawny-crowned Honeyeaters (*Phylidonyris melanops*) and Red Wattle-birds (*Anthochaera carunculata*) visiting *P. microphylla* (= *P.serpyllifolia* ssp. *microphylla*). The only other published report was by Ford *et al.* (1979), who recorded bird pollination (at least in one species) in the Labiatae. Ford (*in litt.*) verified that Black-eared Miners (*Manorina melanotis*), Purple-gaped Honeyeaters and White-fronted Honeyeaters have been observed feeding on the nectar of the flowers of *P. aspalathoides* (sect. *Klanderia*). He also collected probable *Prostanthera* pollen from two Purple-gaped Honeyeaters, one Singing Honeyeater and one Tawny-crowned Honeyeater from Monarto, South Australia (Ford, *in litt.*). Watts (*in litt.*) observed Fuscous Honeyeaters (*Lichenostomus fuscus*) and less frequently, Red Wattle-birds, Tawny-crowned Honeyeaters and Yellow-tufted Honeyeaters (*Lichenostomus melanops*) feeding on the nectar of *P. aspalathoides* in the Inglewood area, Victoria.

I have observed bees visiting flowers of *P. behriana*, *P. lasianthos*, *P. ovalifolia*, *P. rotundifolia* and *P. striatiflora* (all sect. *Prostanthera*). Keighery (1980) recorded eleven insect pollinated *Prostanthera* species, two of which, *P. eckersleyana* and *P. wilkeana* (both sect. *Prostanthera*), were visited by bees and wasps (Keighery, *in litt.*).

The structural floral differences between the flowers of the two sections (Figs 52 & 53) strongly reflect the presumed pollen vectors. Although the pollen vectors appear to be different for each section, the actual mechanism of pollination is thought to be probably very similar throughout the genus.

Pollination mechanism in section *Klanderia*

Birds feed on the nectar produced by the disc, at the base of the gynoecium. As the beak and part of the forehead of the bird enter the flower, the staminal filaments are displaced laterally. This also causes the anthers to be laterally displaced, thus exposing the pollen within the locules. As the bird's beak and forehead brush past the exposed pollen, which is slightly sticky, the pollen is transferred to the bird's beak. When the bird withdraws from the flower the anthers return to their initial position with the dehiscence zones in contact. The lateral displacement of the anthers (hence filaments) is achieved in two ways. Firstly, the corolla mouth is usually narrowest between the lateral lobes. Therefore, the pollen vector comes in contact with the lateral parts of the corolla. This lateral distortion of the corolla actually shortens the distance between the abaxial and adaxial lobes. This shortening brings the anthers into closer contact with the pollen vector. Secondly, this lateral displacement of the anthers is also achieved by the presence of an anther appendage(s) (for examples, refer p. 229). The appendage is more or less

orthogonal to the shortest axis of the corolla mouth. This ensures that the pollen vector will laterally displace these appendages (and hence, the anthers) while probing the flower for nectar. Triangular trichomes are frequently present on the more distal parts of the filaments and on the basal lobes of the anthers. These trichomes probably improve the contact between the stamens and the pollen vector. It is envisaged that this may assist in the dislodgement of the pollen from the locules and so, may result in improved pollen transfer. A similar mechanism was found in *Dicerandra* (Labiatae) from the southern United States of America by Huck (1981). She suggested that the anther appendages (spurs) in this genus (particularly those of *D. odoratissima* which show many similarities to those of *Prostanthera*) ensure an efficient transfer of pollen.

Pollination mechanism in section *Prostanthera*

The main floral structural difference between this section and sect. *Klanderia* is that the flowers of sect. *Prostanthera* have the shortest axis of the corolla mouth between the abaxial and adaxial lobes, not between the lateral lobes. There is still some lateral distortion of the corolla as the pollen vector enters the flower (particularly with Honey bees). However, further comment at this stage would be premature, since more detailed observations are necessary.

Floral biology and ornithophily in section *Klanderia*

Faegri & van der Pijl (1979) have summarized the typical ornithophilous syndrome (also refer Proctor & Yeo 1973). In general, the flowers of the species in section *Klanderia* have characteristics comparable to those of typical ornithophilous species. These characteristics include: a relatively strong more or less tubular corolla (Fig. 53); the lack of floral scent; abundant nectar; the displacement of anthers and stigma from the nectary; the corolla's lacking a landing stage; and the basic colour of the corolla's being red.

According to Faegri & van der Pijl's (1979) classification system of blossom types (pollination units), *Prostanthera* (in fact, most of the Labiatae) have a gullet-shaped blossom (Faegri & van der Pijl 1979, p. 89—I.2.D.,—Fig. 49). Keighery (in Armstrong *et al.* 1982) lists 4 genera of the Prostantheroideae which he regards as having gullet-shaped blossom. In this type of corolla, the androecium, style and stigma (of the gynoecium) are 'restricted to the upper [adaxial] side of the "pollination unit" and pollen is deposited nototribically, on the vector's head' (Armstrong 1979). Although the flowers normally hang down, except in more or less prostrate forms where the corolla mouth is directed upwards (e.g. *P. serpyllifolia* at Innes National Park on exposed limestone cliffs, *P. walteri* on exposed sites), the birds have no difficulty perching (often upside down) on the distal branches while probing the flowers for nectar. The slightly sticky pollen found in flowers of this section, which adheres to the bird's beak, is typical of ornithophilous flowers (Ford *et al.* 1979).

Those flowers which have greenish corollas frequently have calyces which have, at least distally, a red-purple tinge. Therefore, this red-purple tinge may compensate for any effects caused by the masking of the red corolla pigments by contrasting the flower against the green foliage. At least to the human eye, a calyx with a purple tinge is almost as obvious against the green background of the foliage as is a red corolla. This contrast between red (including purple) and green is quite effective and is common in a number of groups. A similar contrast was noted by Conn (1980), with respect to seed dispersal in *Geniostoma* (Loganiaceae).

Raven (1972) pointed out that red and orange colours are not conspicuous to insects, except possibly butterflies. Therefore, flowers of these colours would blend with the green foliage. Furthermore, even if abundant carotenoids are present (as in many orange flowers), their ultraviolet reflectivity (which is conspicuous to insects) is partially, if not

totally masked by the red anthocyanins of the same flowers (Raven 1972). However, red and orange are at least as conspicuous to birds as they are to humans (Knoll 1956; Faegri & van der Pijl 1979), if not more so (Gottsberger 1971).

Several studies (e.g. Grant & Grant 1968) have shown that birds do not necessarily appear to have an intrinsic preference for red, but it is thought that they learn to associate this flower colour with the high caloric rewards of the nectar (Raven 1972). Typical of ornithophilous flowers, those of section *Klanderia* are scentless. Since insects are attracted by odour (Faegri & van der Pijl 1979), they are not aware of the nectar rewards provided by these scentless flowers.

Ford *et al.* (1979) discuss the possible advantages of ornithophily with respect to pollination efficiency, and other related aspects. For instance, they point out that birds can carry more pollen than insects, and so, can pollinate more flowers. They suggest that the production of fewer flowers may be a response which compensates for the increased energy required to produce larger, stronger flowers with greater quantities of nectar. The increased nectar supply being required to adequately provide for the higher energy requirements of birds (Ford & Paton 1976). Ford (*in litt.*) obtained an average nectar content/flower for *P. aspalathoides* (based on 6 flowers) of 8.7 μl with sugar concentrations of 28% by weight of sucrose equivalents. This relatively large quantity of nectar with a corresponding high caloric content is typical of ornithophilous plants. For example, Pyke (1980) obtained an average sugar concentration for plants visited by honeyeaters of 20.4% by weight of sucrose equivalents, and Ford (in Pyke 1980) obtained a value of 21.7%. Paton & Ford (1977) and Pyke (1980) have shown that plants frequented by honeyeaters have nectar with relatively high mean caloric content (overall average 8.4 calories per flower, Pyke 1980). The racemiform inflorescence (of sect. *Klanderia*) may be an adaptation to ornithophily. However, some species of section *Prostanthera* (e.g. *P. spinosa*) have a similarly reduced inflorescence. Ford *et al.* (1979) also suggest that birds visit more flowers (of a population) more frequently than do insects. Observations of birds visiting *P. walteri* and *P. monticola* (sect. *Klanderia*), compared with bees visiting *P. striatiflora* (sect. *Prostanthera*) support this. However, bees appeared to visit plants of *P. lasianthos* (sect. *Prostanthera*) (at Mt Ellery, Victoria) as frequently as the birds for *P. walteri* (also Mt Ellery). Unfortunately, no quantitative data are available, so a comparison is not possible. Although the relative efficiency of birds and insects as pollinators can be measured in terms of frequency of visits to flowers, frequency of visits to separate plants, amount of pollen carried, and so on, a consideration of the relative production of viable seeds would be necessary so that the actual effectiveness of each could be evaluated.

Breeding system in section *Klanderia*

In the absence of a more substantial body of information on the subject, a very preliminary and speculative summary is offered. Since the flowers are protandrous, with the stigma only receptive once the anthers have dehisced, species of section *Klanderia* appear to be essentially outbreeders. This is further ensured because the immature stigma lies between the apices of the anthers and the adaxial surface of the corolla ('above' the anthers). Furthermore, stylar elongation exserts the mature stigma beyond the adaxial corolla lobe-pair without making contact with the staminal dehiscence zones. Hence, the flowers are dichogamous and herkogamous. Therefore, there appears to be no self-pollination mechanism within individual flowers. It seems likely that these ornithophilous species (of sect. *Klanderia*) are dependent for fertilization on visits from the pollen vector, since they lack self-pollination mechanisms within individual flowers. Whether or not flowers which have not been visited by pollen vectors are capable of producing viable seeds is not known. However, the developmental sequence of the racemiform inflorescence is such that flowers at all stages may be present on any individual plant. Therefore,

geitonogamy is potentially possible. In *P. walteri*, birds were observed to visit open flowers, irrespective of maturity. Furthermore, the birds visited several flowers on the same bush before visiting flowers of another bush. Whether or not self-fertilization occurs depends on the level of self-compatibility, although protandry would give a slight advantage to outbreeding.

Seed dispersal and seedling establishment

Labiatae fruits are synaptospermous (all mericarps released as a whole) (Roth 1977). In section *Klanderia* the calyx and the pedicel (a_1 axis + anthopodium) remain attached to the fruit and so fall with the mericarps. Fruits which remain on the plants, after the majority have fallen, usually contain a significantly high number of aborted seeds.

The actual seed dispersal mechanism is not known. In the Dandenong Ranges (Victoria) I have observed bird dispersal of *P. lasianthos* seeds which resulted in successful seedling establishment. However, it seems likely that the mericarps usually fall directly to the ground with very little lateral displacement caused by air-currents.

Seedlings appear to be rare (in sect. *Klanderia*) and usually occur near the base of the parent plant. In *P. behriana* (sect. *Prostanthera*) (at Monarto South, South Australia), seedlings were only found amongst the dead branches (which lay on the ground). It is assumed that these seedlings were not grazed because they were protected by the tangle of branches. However, grazing by wallabies has been observed for *P. spinosa* (sect. *Prostanthera*) on Kangaroo Island, South Australia (refer *Conn 1081-1084*). The soft juvenile shoots of this species are heavily grazed, but the older shoots are protected by the hardened spines. Cunningham *et al.* (1982) note that *P. aspalathoides* and *P. leichhardtii* (= *P. ringens*) are not grazed by stock, but *P. microphylla* (= *P. serpyllifolia* ssp. *microphylla*) is only grazed when other feed is very limited. *P. florifera* appears to be grazed, probably by kangaroos and livestock. In general, more observations are necessary before the extent of grazing and its possible role, if any, in seed dispersal can be evaluated.

Propagation of section *Klanderia*

Although several of the species of section *Prostanthera* are commonly cultivated in public and private gardens, those of section *Klanderia* are only sometimes found in public gardens, rarely in private gardens. There appear to be no cultivars involving species of this section. The techniques used to cultivate *Prostanthera* species are discussed in Althofer (1978), Anon. (1971) and Anon. (1977).

Numerical Analysis

Introduction

In numerical taxonomy, any biometric analysis which attempts to organize individuals into groups is regarded as classificatory. There are many aspects specific to numerical classification which are discussed in Williams (1971, 1976). These are not discussed here because they do not represent further differences from non-numeric concepts of classification. Lance & Williams (1967) also include the simplification of the data by ordination as a type of classification. However, ordination does not necessarily lead to the recognition of groups within the sample being tested. The principal difference between classification and ordination is that the former is concerned with the organization of individuals into groups, whereas the latter is concerned with the relationship between the individuals.

One important feature of a non-numerical classification is that the discrete groups are arranged relative to each other after being assigned to a certain rank. In numerical phenetics, hierarchical classification (Williams 1971) presents a similar arrangement which can be readily expressed in two dimensions in the form of a phenogram. However, the individuals are arranged relative to a set of ultrametric distances which define the phenogram. These ultrametric distances are the transformed set of pair-wise dissimilarities (Sneath & Sokal 1973). McNeil (1978) clearly summarized the differences between non-numeric classification and phenograms as (i) classifications are rank-defined, whereas (ii) phenograms are distance-defined. The distance value of a phenogram is the 'actual fusion-level derived from the distance or dissimilarity being used' (McNeil 1978).

McNeil (1978) added to Farris' (1977) definition of classification that a 'phenetic classification should also have a predictive element'. This is similar to Dagnelie's (1966) identification concept for numerical classification. Therefore, McNeil's definition is preferred since it is comparable to that used by most non-numerical taxonomists.

Selection of morphological characters

An estimate of resemblance between organisms is based on a consideration of as many features as possible of the individuals concerned. In classical taxonomy these features are usually known as taxonomic characters, whereas the literature of numerical taxonomy contains a number of terms (e.g. character, attribute, variable) which have been variously defined and hence, applied differently by different authors. The term character has been most commonly used as 'a property which differentiates a taxon of any rank from at least part of the taxa of the same rank which are all subordinated to the same taxon at the next higher level' (Leenhouts 1968). A similar definition was used by Mayr (1969). In this sense, characters are defined as the *differences between taxa*, but as pointed out by Sneath & Sokal (1973), 'the taxa cannot be recognized without the characters themselves being first known'. Therefore, this definition is inappropriate.

In this study, a definition similar to that of Cain and Harrison (1958) is used. That is, a *character* is regarded as 'any attribute (or descriptive phrase) referring to form, structure or behaviour which the taxonomist separates from the whole organism for a particular purpose such as comparison or interpretation' (Davis & Heywood 1963). Therefore, character is here used in a similar sense to that of attribute, as used by Clifford & Stephenson (1975), and Williams (in Williams 1976). Hence, character states are the expression or nature of the character concerned and are not used in the sense of Jardine (1969). Sokal and Sneath (1963) proposed the term *unit character*. Although the concept is possibly theoretically sound, it seems likely that division of characters into units will frequently be difficult. Therefore, as a working definition, the more general definition of Davis and Heywood is preferred.

Pre-numerical analysis

Prostanthera section *Klanderia* was initially studied using classical (non-numerical) taxonomic procedures (refer p. 211 for details of general procedure followed). The amount of herbarium material available for study was far too much to be taxonomically analysed as one unit. Hence, the material was initially sorted into broad geographical units. These units mostly corresponded with State boundaries, although more natural geographical units such as mountains, mountain ranges and islands were also used. Each unit was of a more manageable size than the unsorted material since (within each unit) there are fewer taxa to be dealt with or, in the case of widespread species, less variation than expressed over its entire area of distribution. Within each unit duplicates and population collections were grouped together so that a more reliable impression of the morphological variation within either individuals or populations could be achieved. Finally, entities (specimens or

populations) which showed a strong mutual gross morphological resemblance were grouped together. Entities which appeared intermediate between any two groups were kept separate and were carefully compared with each group at a later stage. Many of these intermediate entities occurred near State boundaries of what proved to be more widespread species (e.g. *P. aspalathoides*). Several of the groups formed as a result of the above sorting proved to be morphologically homogeneous within each group, as well as morphologically distinct from the other groups. These groups are recognized as distinct species (*viz. P. chlorantha, P. florifera, P. grylloana, P. monticola, P. porcata, P. ringens* and *P. walteri*).

The choice of characters and the final character set used are discussed below and in Table 1. With the exception of those characters involving density of hairs and glands, all characters listed in Table 1 were used in this non-numerical taxonomic analysis and so form the basis of the botanical descriptions.

The remaining (less homogeneous) groups, including *P. florifera* (refer Fig. 5 for locality of groups) were analysed in more detail by numerical techniques (refer pp. 231-245). These largely arbitrary groups were used to evaluate the character set (pp. 227-231) and to evaluate the suitability of these groups as classificatory units (pp. 231-237). The modified classification which arose out of these analyses (pp. 235, 236) resulted in three species complexes being recognized (*viz. P. aspalathoides, P. calycina-P. microphylla-P. serpyllifolia*, and *P. laricoides*). The morphological structure of each of these was than analysed in further detail (pp. 237-245).

Method used to select morphological characters

During the initial classical taxonomic analysis of sect. *Klanderia* a general overview of this section was obtained and various taxonomic problems were located. In addition to this, characters were evaluated for their taxonomic usefulness based on knowledge gained from my preliminary taxonomic investigation of this section.

The selection of characters was based on a number of criteria. The only characters used were those which could be consistently measured so as to represent unambiguously the relevant feature. It was found that corollas could not be measured so as to represent consistently and accurately the true shape. A number of factors determine the ultimate corolla shape. Maturity and position of the corolla, relative to the foliage and branches, are two of the most important factors which may lead to changes of the corolla shape. The extent of recurvature of the corolla lobes is another factor which determines the overall shape of the corolla and it was not possible to measure accurately the extent of this recurvature. Furthermore, this feature appears to be correlated with anthesis and fertilization. The problems that I have encountered in trying to use the various aspects of corolla shape as taxonomic characters, commonly occur in many groups which have bilabiate corollas. Ideally, fresh material which has been grown under controlled conditions is necessary. Although many collections were specifically made for this study (alcohol preserved material being available for most of these), intensive collecting would have been necessary to ensure that suitably preserved corollas would be available for a much larger data set. Unfortunately, this was not feasible during this study.

Since I was in part relying on herbarium material, of which some was not collected specifically for this study, I chose characters which were present on most of the collections. Finally, I avoided characters which appeared to be invariable (e.g. those of fruits, hence mericarps; those of seeds; and magnitude measurements of corolla tube, mouth and lobes). The invariability of such characters was determined by measuring selected specimens from different taxa.

The level of correspondence between the various character states and the different taxa was not known. For example, *P. aspalathoides*, *P. microphylla* and *P. serpyllifolia* are

usually differentiated on the basis of the size and shape of the leaves, and the presence or absence of an anther appendage. However, during my preliminary study it was noted that it was frequently difficult to classify certain specimens into any of these three taxa on the basis of leaf length or shape. Furthermore, specimens which appeared to belong to *P. aspalathoides* on leaf characteristics, had short anther appendages whereas other similar specimens lacked this appendage. Traditionally, *P. microphylla* (= *P. serpyllifolia* ssp. *microphylla*) is usually distinguished from *P. aspalathoides*, at least in part, by the former taxon having an anther appendage and the latter, supposedly lacking this appendage. Therefore, my preliminary study indicated that should a difference exist between these two taxa, with respect to the anther appendage, then it was more likely to be quantitative than qualitative.

The taxonomic importance of the various aspects of indumentum (glandular and eglandular) was more uncertain than most of the above characters. As mentioned before, there are differences between taxa with respect to the position of the hairs on the branches, and some taxa have glabrous branches whereas others were hairy. Similarly, differences in the shape of the hairs on the branches were of unknown importance. Therefore indumentum characters were included in the final character set so that they could be rigorously evaluated by biometrical techniques.

The raw data is not included because of its bulk, but it is available from MEL on request. The morphological characters used are listed, with brief explanations in Table 1. The density of hairs and glands were measured using a glass ocular graticule. The number of hairs or glands in one millimetre square were counted and the average of five separate density measurements were used. The other features (refer Table 1) are self-explanatory and so will not be discussed further.

Table 1. Final character set used in the various biometrical analyses

AAL	length of anther appendage (mm), if two appendages then length of longest appendage
BL	length of prophyll (mm)
BLW	length to width ratio of prophyll
INTER	position of hairs on branches—hairs absent (0), hairs on two opposite sides (1), hairs on all sides (2)
KGDO	density of glands on outer surface of calyx (number of glands/mm²)
KHDI	density of hairs on inner surface of calyx (number of hairs/mm²)
KHDO	density of hairs on outer surface of calyx (number of hairs/mm²)
KL	length of calyx (mm)
KLLT	length of calyx lobes to length of calyx tube ratio
LGD	density of glands on leaf (number of glands/mm²)
LHD	density of hairs on leaf (number of hairs/mm²)
LKLP	position of prophyll on pedicel (anthopodium length divided by a_1 axis) (see Fig. 2B)
LL	length of lamina (mm)
LLW	ratio of lamina length to maximum width of lamina
LLWL	position of maximum width of lamina (distance maximum width of lamina from base divided by length of lamina)
LPLL	length of petiole to length of lamina ratio
PL	length of pedicel (mm) [anthopodium + a_1 axis] (see Fig. 2B)
STBB	length from base of hair to first bend of hair (mm). Hairs of branches measured
STGD	density of glands on branches (number of glands/mm²)
STHD	density of hairs on branches (number of hairs/mm²)
STHL	length of hairs on branches (mm)
STHW	basal width of hairs on branches (mm)
STMX	maximum distance any part of hair (of branches) is from surface of branch (mm)

Evaluation of character set

Since the characters used form the basis of the subsequent classification, these characters were critically evaluated for both their validity and their taxonomic value. The assessment of the characters included a consideration of the discriminatory 'power' (or uniqueness of the information content of each), the variability of each, and the extent of redundancy of information in the characters as a whole.

Initially, the fundamental distributional characteristics of the characters (of the individuals examined) were analysed (using subprogram CONDESCRIPTIVE, Nie *et al.* 1975) and some of the statistics are presented in Table 2. The significance of the deviation from normality of kurtosis and skewness where tested using the *t*-test (as modified by Sokal & Rohlf 1969). All characters were nonparametrically distributed. Therefore, statistical tests which assume normality were not used, except on transformed data (that is, data standardized by range, refer pp. 236 & 245).

Bivariate correlation analysis was used to evaluate the extent of the redundancy of information for each character. The nonparametric rank-order correlation coefficients of *Kendall's tau* were computed (using subprogram NONPAR CORR, Nie *et al.* 1975). *Kendall's tau* gives a measure of how similar any two characters are without making any assumptions about the distributional characteristics of the characters. The most common significance test is whether a sample correlation coefficient could have come from a population which has a correlation coefficient equal to zero (that is, $H_0 : \rho = 0$). A *t*-test with n - 2 degrees of freedom was used to test the hypothesis (refer Bailey 1959; Sokal & Rohlf 1969). Those pairs of characters with the highest correlation coefficients (those greater than 0.4 or less than -0.4, at the 0.001 significance level) are presented in Table 3. No character pairs varied significantly from zero. Therefore, all characters appear to provide a high level of 'uniqueness' with respect to their information content.

Table 2. Various statistics of the complete character set. For explanation of the character abbreviations, refer Table 1.

Character	Mean)	Range	Standard Error (Standard Deviation of Mean)	Standard Deviation (Variance)	Kurtosis	Skewness
INTER	1.77	0-2	0.02	0.50	3.49	-2.07
STHD	105.68	0-468.81	2.38	58.43	6.81	1.66
STGD	32.24	0-174.18	1.06	26.13	4.83	1.97
LPLL	0.06	0-0.52	0.003	0.07	2.44	1.16
LL	4.27	1-19	0.10	2.39	3.34	1.37
LLW	5.02	1-31.25	0.15	3.71	7.60	1.92
LLWL	0.48	0-4.33	0.01	0.30	56.17	4.95
LHD	18.22	0-486.09	1.39	34.18	88.77	7.85
LGD	42.57	1.89-230	1.13	27.76	11.76	2.75
PL	2.80	0.75-13	0.08	1.88	10.84	2.98
BL	2.56	0.5-5.25	0.03	0.63	1.57	0.23
BLW	5.26	1.6-11.67	0.06	1.40	1.49	0.51
LKLP	0.07	0-1.31	0.01	0.15	23.12	4.07
KL	7.43	3.95-13	0.06	1.37	1.19	0.87
KLLT	0.64	0.14-1.1	0.01	0.14	1.04	0.06
KHDO	15.38	0-219.28	1.13	27.82	16.41	3.38
KGDO	16.31	1.9-132.5	0.55	13.58	22.22	3.95
KHDI	10.15	0-533.89	2.02	49.61	47.14	6.42
AAL	0.36	0-2.5	0.02	0.38	2.53	1.38
STHW	0.31	0-0.11	0	0.01	3.51	0.19
STHL	0.21	0-0.53	0.01	0.09	1.77	0.55
STBB	0.09	0-0.47	0.01	0.05	9.94	1.51
STMX	0.12	0-0.74	0.01	0.06	20.87	2.25

Table 3. Correlation coefficients for selected character-pairs. For explanation of character abbreviations, refer Table 1.

Character — Pair	Kendall's Tau
INTER — KHDI	- 0.4834
LPLL — LLW	- 0.5498
LL — LLW	0.6359
LL — LHD	- 0.4054
BL — BLW	0.5029
STHW — STHL	0.4945
STHL — STBB	0.4374
STBB — STMX	0.5794

The most variable characters are hair and glandular density of the branches, leaves and calyx (Table 2). The amount of variability and reliability of a character as a deliminator of taxa is usually assessed by the variance-ratio or *F*-test, which is an analysis of variance (refer Williams & Stephenson 1973; Stephenson *et al.* 1974). The *F*-test considers the ratio of the between-group variance to that of the within-group variance. However, since this test assumes that the within-group values are normally distributed, in most instances it was not used to evaluate the taxonomic usefulness of the characters for the complete data. However, the *F*-test was used in the stepwise options of subprogram DISCRIMINANT (Klecka [& Tuccy], in Nie *et al.* 1975). The selection of the characters giving the best separation of the groups was achieved by the use of WILKS and RAO stepwise methods of subprogram DISCRIMINANT (Klecka [& Tuccy], in Nie *et al.* 1975). In the above two stepwise methods, the independent characters are selected for inclusion into the Canonical variate analysis on the basis of their discriminating power. The WILKS method takes into account the differences between the centroids and the homogeneity of the groups, whereas RAO emphasises the greatest separation of the groups. For futher details of these two methods refer Klecka, in Nie *et al.* 1975.

The results of both step-wise procedures are summarized in Table 4 (only the first 12 characters are presented). The discriminatory power of all characters (except LGD and BLW, which had 'F TO ENTER' values of 0.7019 and 0.7808, respectively) is high since Wilk's lambda is low. The change in Rao's *V* indicates that the change in distance between group centroids is statistically significant. All characters were retained for further analyses (unless otherwise stated) because there was no obvious 'cut-off' point. Information concerning the first three extracted canonical variate functions is given in Table 5. Changes in Wilk's lambda (associated with the chi-square significance test) indicate that the characters being used have considerable discriminatory power, at least for the first

Table 4. Statistics of the first 12 characters selected by Canonical variate analysis (significance of Wilk's Lambda and change in Rao's *V* is 0.000). Refer Table 1 for explanation of character abbreviations.

Character Step No.	entered	Wilks *F* ratio	Lambda	Change in Rao's *V*	Rao's *V*
1	KHDI	86.5099	0.24295	1816.71	0.1E+04
2	LPLL	77.7913	0.06900	3303.99	0.1E+04
3	INTER	68.0464	0.02437	4775.13	0.1E+04
4	KGDO	52.6431	0.01436	5807.01	0.1E+04
5	KHDO	51.0544	0.00557	6760.21	953.1987
6	LKLP	46.1469	0.00295	7610.29	850.0809
7	KL	42.3132	0.00165	8162.18	551.8912
8	LLWL	38.0996	0.00111	8660.18	498.0020
9	AAL	34.8443	0.00076	9151.25	491.0680
10	STHL	32.1295	0.00054	9540.86	389.6039
11	KLLT	29.7643	0.00041	9896.58	355.7237
12	STMX	27.6719	0.00032	0.1E+05	235.0866

Table 5. Statistics of the first three Canonical variate functions (significance of Wilk's Lambda is 0.000).

Canonical variate function	Eigenvalue	% of variance	Canonical correlation	Wilks Lambda	Chi-squared	D.F.
1	6.81100	36.49	0.93379	0.00122	3906.0	400
2	4.21830	22.60	0.89909	0.00639	2943.6	361
3	2.44118	13.08	0.84226	0.02198	2223.7	324

Table 6. Standardized Canonical variate coefficients for function 1 of the 13 most important characters.

Character	Function 1
KHDI	-0.63857
KGDO	-0.45391
INTER	0.44090
LKLP	-0.24470
STHW	0.14436
STHL	0.13829
LHD	0.12477
LPLL	0.11991
AAL	0.11476
LLW	0.07819
KLLT	0.07706
BL	-0.05880
STHD	0.05612

three functions. The eigenvalues (a measure of the relative importance of the canonical variate function) indicate that the first three functions (in particular, function 1) are very important when considering the complete data set. The characters which contribute most to the first standardized canonical variate function are KHDI, KGDO, INTER, and LKLP (Table 6). However, all coefficients are relatively low and no single character or group of characters are obviously more important than the majority of other characters. Rather, a number of characters are collectively important discriminators in function 1. A similar trend was found in functions 2 and 3.

Principal component and principal factor analyses (using the various options of subprogram FACTOR, Kim, in Nie *et al.* 1975) were used to determine the contribution of each character to the overall variance of the character set. Those characters which contribute the least to the overall variance are the least efficient in delimiting taxa.

The PA2 method of subprogram FACTOR (Kim, in Nie *et al.* 1975) was used because it uses an iteration procedure for improving the estimates of communality. Only those factors with eigenvalues > 1 were extracted (MINEIGEN = 1), since factors with eigenvalues less than 1 account for less of the total variance than does a single character. Option VARIMAX (of subprogram FACTOR) was used to maximise the contribution of the first factor. This option rotates the axes orthogonally. As there was no prior reason to assume that there was correlation between factors, this option (VARIMAX) was used rather than option OBLIQUE (which assumes that factors are correlated).

The first three axes (factors) of principal factor analysis account for 33% of the variance. Characters KHDI, LPLL and INTER loosely cluster in the plot of factor 1 versus factor 2 (not presented here). STHL, KLLT and STMX also loosely cluster on this same plot. However in general, there was very little clustering of characters on the three factors.

After consideration of the statistics from the various analyses (as discussed above) all

characters were retained to form the final character set (Table 1). However characters STBB, STHL, STHW and STMX (all referring to features of the hairs on branches) were not used in analyses which included specimens with glabrous stems. All characters are numeric (= numeric attribute, Williams, in Williams 1976), except for INTER which is ordinal (= ordinal attribute, Williams, in Williams 1976).

Numerical analyses of specimens

A number of species, (*viz. P. chlorantha, P. florifera, P. grylloana, P. monticola, P. porcata, P. ringens,* and *P. walteri*) were sufficiently distinct using non-numerical procedures that further detailed biometrical analyses of these taxa were not necessary. However, *P. florifera* was included in the initial biometrical analyses so that additional clarification of the distinctness of this species from *P. aspalathoides* could be achieved. The complexes which were studied in detail included the following taxa (as circumscribed by Bentham 1870): *P. aspalathoides s. lat.* (incl. the *P. laricoides* complex of Western Australia), *P. calycina, P. microphylla,* and *P. serpyllifolia.* Initially the specimens (refer Conn 1982, pp. 258-264) were assigned (using non-numerical methods) to 23 groups. These groups were morphologically defined using a relatively 'narrow' concept, and they included a consideration of distribution. Therefore, the 23 groups were a reflection of apparent morphological similarity and, in most cases, approximately represented geographical regions (Fig. 5 and p. 225). This initial classification was tested using canonical variate analysis.

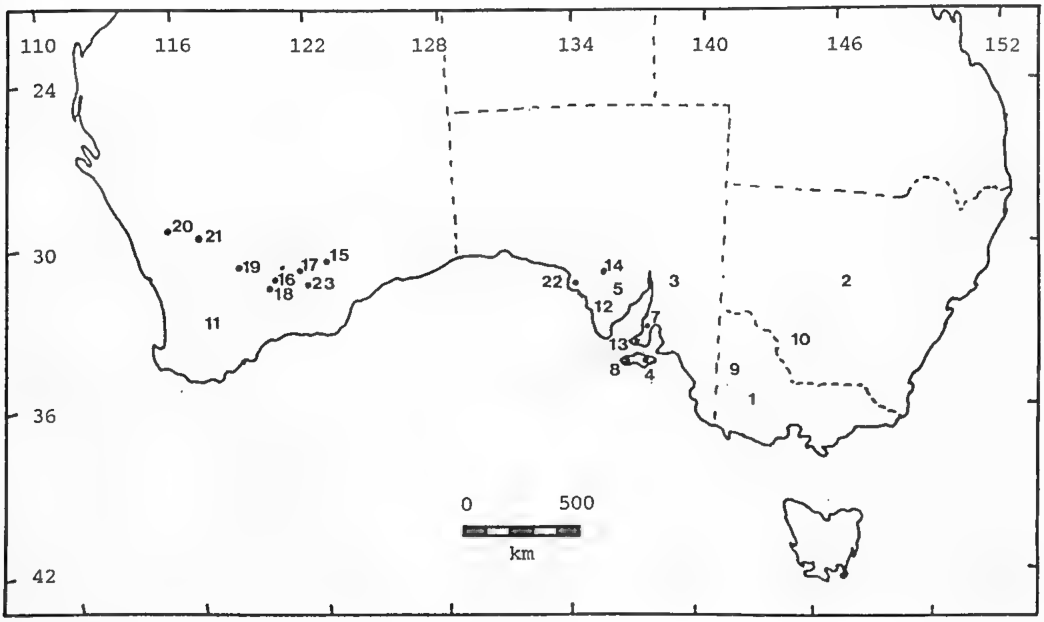


Fig. 5. Locality details of the 23 groups of the *P. aspalathoides, P. calycina—P. microphylla—P. serpyllifolia,* and *P. laricoides* complexes. Symbols are: *P. aspalathoides* — 1 = Victorian specimens, 2 = specimens from New South Wales, 3 = mainland South Australian specimens, 4 = Kangaroo Island specimens; '*P. microphylla*' — 5 = Eyre Peninsula specimens, 6 = Fleurieu Peninsula specimens, 7 = Yorke Peninsula specimens, 8 = Kangaroo Island specimens, 9 = Victorian specimens, 10 = specimens from New South Wales, 11 = Western Australian specimens; *P. serpyllifolia* — 12 = Eyre Peninsula specimens, 13 = Innes National Park specimens; 14 = *P. florifera*; 15 = *P. laricoides*; 16 = *P. semiteres*; 17 = *P. incurvata*; 18 & 19 = *P. semiteres*; 20 = *P. pedicellata*; 21 = *P. patens*; 22 = *P. calycina*; 23 = *P. incurvata.*

Canonical variate analysis (also known as multiple discrimination analysis) is a statistical technique which is used to test the significance of the differences between the (*a priori*) groups of the classification over all characters. It is not a pattern analysis (as used by Williams & Gillard 1971) or a classificatory technique because it arises when a classification already exists. The weighting [discriminant] coefficients computed are derived so that within-group variance is minimal and conversely, between-group variance is maximal. Sneath (1964) criticized the validity of this type of character weighting. He pointed out that characters cannot be weighted on the basis of their *within*-group constancy since it involves the *a priori* assumption of defined groups (cf. Leenhouts' definition of a character, refer p. 225. However, since it can be assumed that each of the replicate samples (of individuals or populations, refer p. 211) used in this study represent one taxon, these replicates provide a useful means by which the suitability of any classificatory technique can be checked. This technique for checking classifications has been used and recommended by several workers (e.g. Farris 1966; Sandland & Young 1979; Johnson 1982).

The DIRECT method of subprogram DISCRIMINANT (Klecka [& Tuccy], in Nie *et al.* 1975), in which all characters presented are entered concurrently into the analysis, was used to test the initial classification.

The relationship between the groups, as expressed by canonical variate functions 1 and 2 is illustrated in the resulting scattergram (Fig. 6). The most striking feature of this scattergram is the separation of the Western Australian taxa (groups E - K & M) (Fig. 6) from the South Australian-eastern States taxa (with the exception of group A [from Western Australia] which is placed with the South Australian groups).

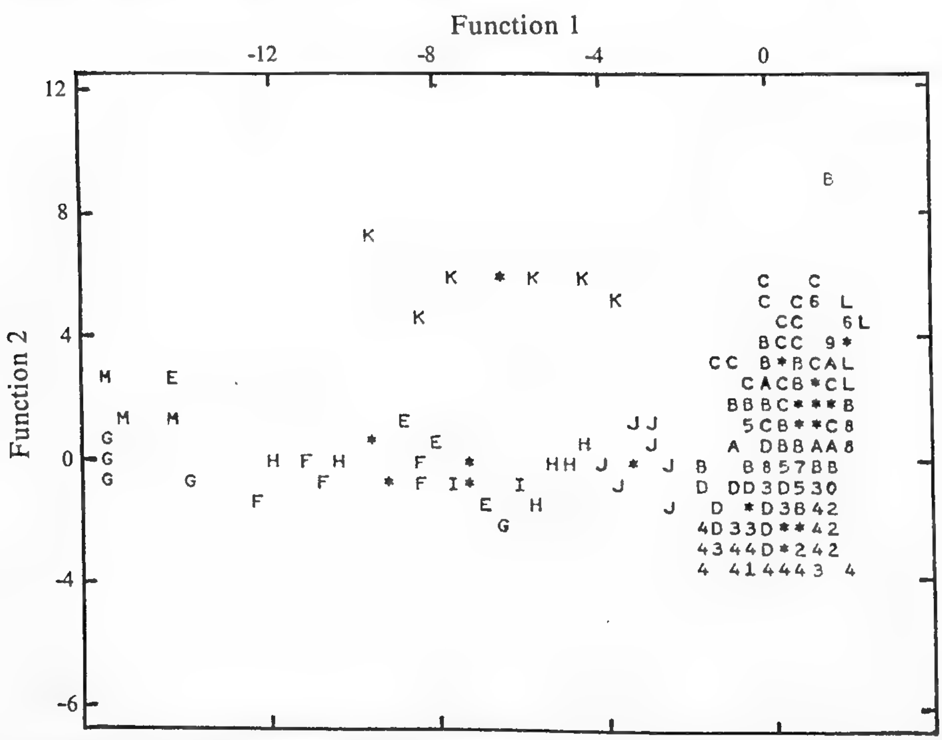


Fig. 6. Canonical variate scattergram (function 1 versus function 2) of the initial 23 groups of *P. aspalathoides*, *P. calycina—P. microphylla—P. serpyllifolia*, and *P. laricoides* complexes. For details of taxa refer Fig. 5. 1 = 1; 2 = 2; 3 = 3; 4 = 4; 5 = 5; 6 = 6; 7 = 7; 8 = 8; 9 = 9; 0 = 10; A = 11; B = 12; C = 13; D = 14; E = 15; F = 16; G = 17; H = 18; I = 19; J = 20; K = 21; L = 22; M = 23; * = group centroid.

The four characters which contribute most to the first three canonical variate functions are given in Table 7. All the Western Australian taxa (excluding group A) have the inner surface of the calyx hairy. The analysis was repeated deleting character KHDI, to evaluate the importance of this character in determining this division into two major groups. As can be seen from figure 7, this basic delimitation is maintained. The specimens of the Western Australian groups (groups E-K & M) (Figs 6 & 7) have tended to separate into several clusters. The remaining specimens have also tended to form several clusters.

Table 7. Standardized canonical variate function coefficients for the four most important characters, for the first three functions.

Function	Character	Standardized canonical variate function coefficient
1	KHDI	-0.76520
	KGDO	-0.41096
	INTER	0.33935
	LKLP	-0.16367
2	LPLL	0.71354
	AAL	0.37924
	LLWL	-0.33051
	STMX	-0.30192
3	KHDO	0.71665
	LKLP	0.59342
	KHDI	-0.22818
	KL	-0.19023

However, these groups are not resolvable into clearly separable clusters (at least on the first two functions) because of scaling limitations. Therefore, the infrastructure of these groups is dealt with separately so as to improve resolution. However, a simplification of the infrastructure was achieved by a consideration of the canonical variate [discriminant] distances between group centroids. A modification of the original computer program DISCD (written by P. Lang, Adelaide University) was used to compute euclidean distances in D-space between all pairs of group centroids (using the canonical variate functions for group means). The length of the line between any two centroids (measured in discriminant units) being equal to the square root of Mahalanobis' D^2. The nearest-neighbour phenogram (modification of 'Single linkage clustering' of Florek *et al.* 1951a, 1951b; and Sneath 1957) (Fig. 8) which was generated from the canonical variate distance matrix, summarizes the distances between the various group centroids. The advantage of the computed distance metric is that it is a summation of all the character differences, whereas the canonical variates are only concerned with characters which distinguish groups. The most serious limitation of this phenogram is that the distances are based on the means of the various groups when the critical delimitation of complexes should take into consideration the 'boundary' and extent of overlap (if relevant) between the various taxa. It must be remembered that distances based on group centroids could be potentially misleading because they may over-emphasize the distinctness of groups. However, the nearest-neighbour phenogram does assist in the interpretation of the canonical variate scattergram.

The determination of the number of taxa which should be recognized in a distance (dissimilarity) based phenogram is a major problem in numerical taxonomy. Sokal & Sneath (1963) advocated the use of a phenon line. They nominated all groups produced by that line as phenons. Unfortunately, the relationship between phenons and taxa is frequently rather obscure. However, one of the most serious objections to this technique is that, without some prior understanding of the taxonomy of the group being investigated, there

is no way to predict where the phenon lines should be placed. Furthermore, unless the fusion strategy used is strictly space conserving, the drawing of phenon lines is invalid due to group-size dependence (Clifford & Williams 1973; Clifford, in Williams 1976). Ratkowsky & Lance (1978), using the Cramér measure (Cramér 1946) for the degree of association, developed a criterion for determining the 'optimum' number of groups in a phenogram without requiring prior knowledge of the taxonomy of the specimens concerned. However, they still required the application of the phenon line to determine the groups for which the Cramér measure is calculated. Hill (1981) modified the Ratkowsky & Lance criterion so as to overcome the invalid use of phenon lines. Although

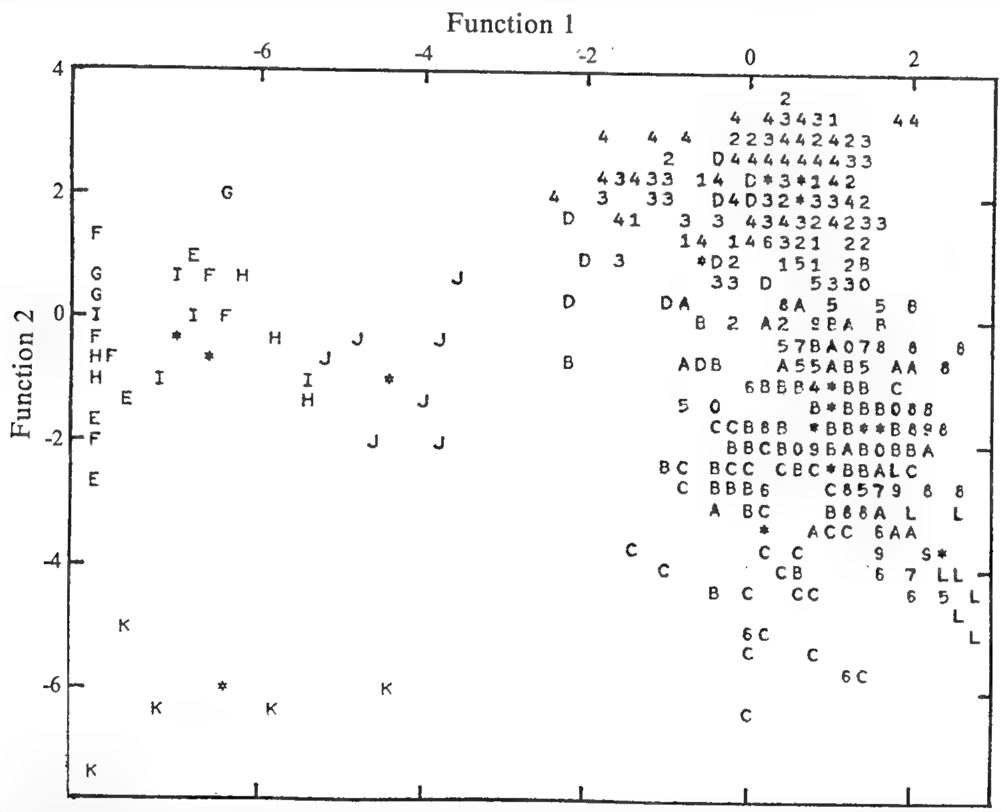


Fig. 7. Canonical variate scattergram (function 1 versus function 2) of 22 groups of the *P. aspalathoides*, *P. calycina*—*P. microphylla*—*P. serpyllifolia*, and *P. laricoides* complexes with KHDI character deleted from the analysis. For details of the taxa refer to Figs 5 & 6, however note in this figure that groups 17 and 23 are collectively designated by the letter 'G'.

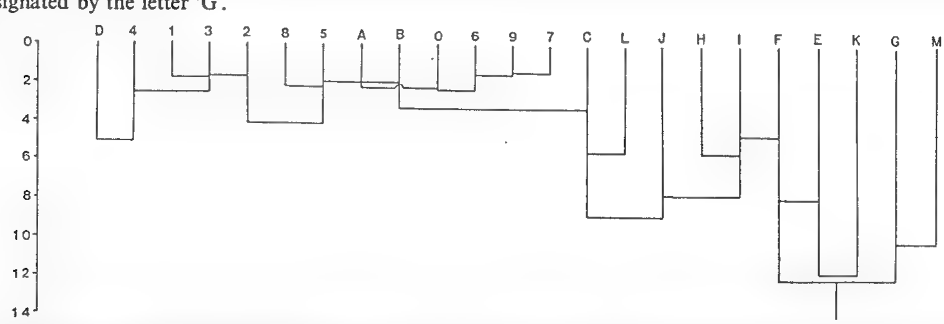


Fig. 8 Nearest-neighbour phenogram generated from the Canonical variate distance matrix of the initial 23 groups. For details of the taxa refer to Figs 5 & 6.

Hill's modification appears to improve the estimation of the number of groups in a phenogram, his criterion was unable to distinguish the specimens of *Pittosporum rhombifolium* (Pittosporaceae) from *Tristania conferta* (Myrtaceae) (refer Hill 1980), two unrelated taxa. Therefore, it seems doubtful that his criterion would be of any value when dealing with closely related taxa, as found in species complexes. Neither criteria were used to determine the number of taxa. Rather, the classification of replicate samples (as used by Sandland & Young 1979; Johnson 1982) was used to decide subjectively the number of taxa which should be recognized.

Based on distances, the Western Australian groups (excl. group A) remain distinct from the other groups (Fig. 8). Furthermore, the relatively distinct clusters within the Western Australian specimens (Fig. 6) are supported by the relatively large distances between the centroids of these groups (Fig. 8). The homogeneity of the other groups (Fig. 6) is verified by the variance of distance values being quite low, as shown in figure 8. However, the structure of the groups is clearer in the phenogram (Fig. 8). Groups 1-4 are very similar to each other and, on the basis of nearest-neighbour distances, appear to represent one taxon (*P. aspalathoides*) (Fig. 8). This is also supported, but less clearly by the canonical variate scattergram (Fig. 6). Group D (*P. florifera*) is most similar to *P. aspalathoides* (groups 1-4) (Fig. 6); however, the former appears to be a distinct taxon on the basis of the nearest-neighbour distances (Fig. 8). Groups 5-B and possibly C appear to represent another taxon (*P. serpyllifolia*), whereas group L. (*P. calycina*) is quite distinct from the previous groups on the basis of distance values. The distinctness of

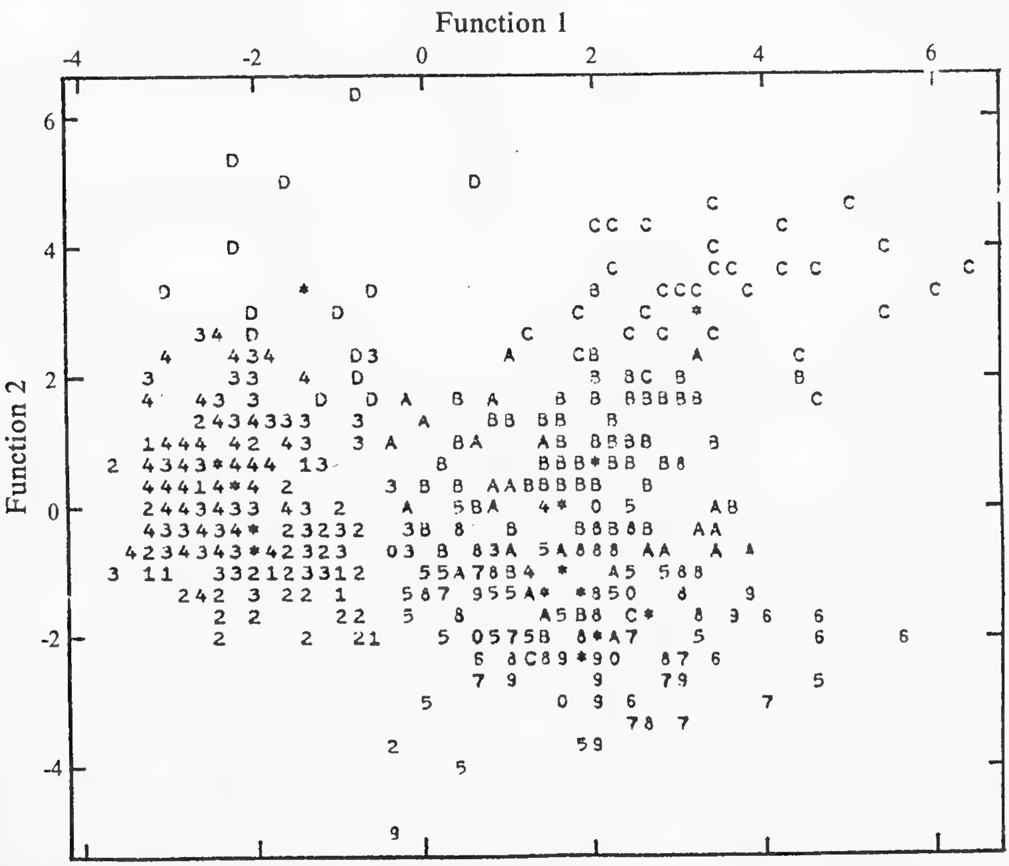


Fig. 9. Canonical variate scattergram (function 1 versus function 2) of the first fourteen taxa (Taxa 1 to D). For details of the taxa refer to Figs 5 & 6.

groups 1-4 from groups 5-C was also evaluated using canonical variate analysis by (1) only including specimens of groups 1-D (Fig. 9), and by (2) only including specimens of groups 1-8 (Fig. 10). The increased scaling improved the resolution such that groups 1-4 (*P. aspalathoides*) is regarded as distinct from groups 5-C (*P. serpyllifolia* (particularly evident in Fig. 10), and that group D (*P. florifera*) is a distinct taxon (particularly evident in Figs 6 & 7, also refer p. 312. The Western Australian groups (excl. group A) represented a distinct entity (refer Figs 6 & 8) which was studied in more detail (see below).

Scattergrams of functions 1 and 3 (not presented here) further supported the distinctness of the above groups.

A number of computer programs were used in the following detailed analyses of the morphological variation within each of the above species and species complexes. Some of these programs have been discussed in the previous section (e.g. those used for canonical variate analysis and principal component analysis).

The data (of the original 23 characters) were standardized by range (0 ≤ character state ≤ 1) so as to minimise the effect of isolated strongly deviant values. The population means for each character were weighted by the *F*-1 value (Adams 1975). All characters with *F* values less than 1 (at the 0.01 level) were not used in subsequent analyses.

A matrix of Manhattan metric distances was calculated between the individuals [using program TAXDT (refer Whiffin 1978), which utilizes the d_1 (*j, k*) formulation of Sneath and Sokal 1973]. Williams and Clifford (in Williams 1976) showed that the Manhattan metric measure, using range-standardized data, is less affected by 'out-lying' values than some other measures (e.g. Bray-Curtis measure). This matrix was then used to group the populations, using the overall similarity of the individual specimens, in the form of hierarchic non-overlapping clusters. This was graphically presented as a phenogram.

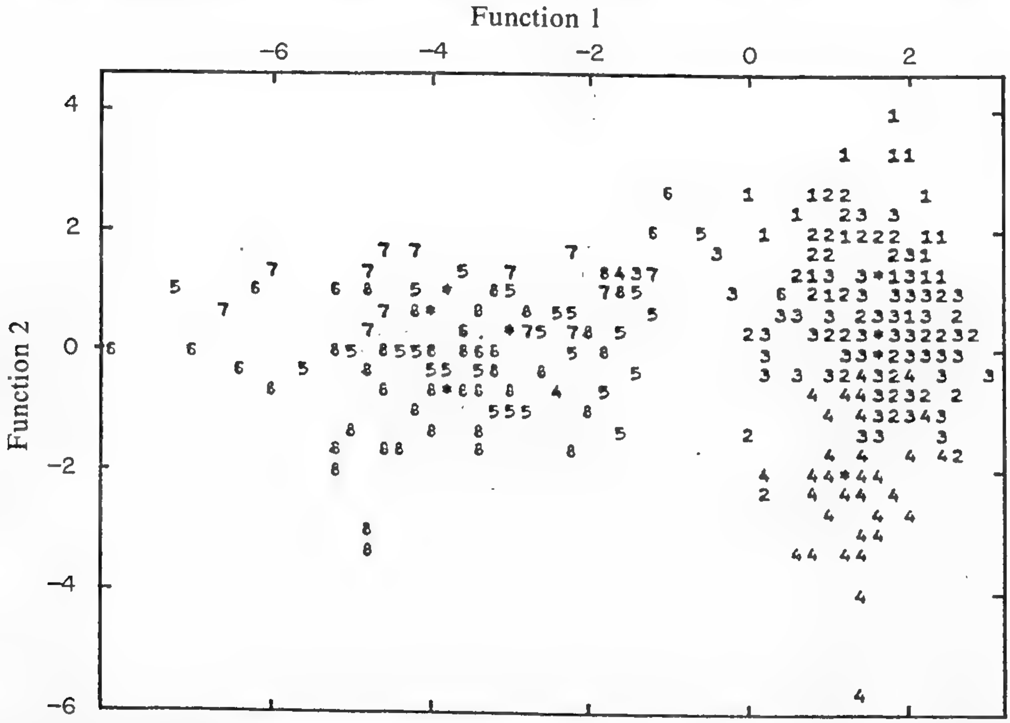


Fig. 10. Canonical variate scattergram (function 1 versus function 2) of the first eight taxa (Taxa 1 to 8). For details of the taxa refer to Figs 5 & 6.

The matrix was subjected to a principal coordinates analysis (Gower 1966, 1967, 1969) (using programs GOWORD or GOWER—refer Williams *et al.* 1971) to produce an ordination of the individuals. The results of this ordination were graphically presented (using program ORDX—refer Whiffin 1978).

The above methods used all available characters (with *F* values greater than 1, at the 0.01 level) to determine the phenetic relations among the populations.

Numerical analysis of *Prostanthera aspalathoides*

The canonical variate scattergrams (Figs 7, 9 & 10) and the nearest-neighbour phenogram (Fig. 8) suggest that *P. aspalathoides* is very homogeneous, with the Kangaroo Island populations (population 4—refer Figs 8 & 10) slightly distinct from the other specimens. The infraspecific structure of *P. aspalathoides* was examined in more detail. 190 specimens from 22 populations were analysed (Fig. 20). The number of specimens in each population and the localities of each population are listed in Table 9. Using principal component analysis, the characters exhibiting high component scores (on the first three components) included INTER, LL, LLW, BL, BLW, LLKP, KL, STHL, STBB, STMX (refer Figs 11 & 12). Therefore these characters contribute most to the total variance of the specimens. STHL and STMX were highly intercorrelated on all components and so STMX was deleted from subsequent analyses. KHDI was also deleted because it was invariant within this species. Canonical variate analysis of the 22 populations produced some clustering on the first two functions (Fig. 13). The Kangaroo Island specimens (I, J) form a weakly distinct cluster. Similarly, the population from Bordertown, Kiata, and the Little Desert (A, 9, 0, respectively) also form a more or less distinct cluster. Only 50.7% of the specimens were correctly classified (according to the canonical variate classification results, refer Nie *et al.* 1975). This low value is to be expected since it would not be realistic to expect each population to be distinct. Although classification results are frequently of minimal value, especially in this type of situation, the result of the reclassification of the populations may (indirectly) indicate relationships. For example, in most cases the reclassification was to a nearby population. However, with respect to the Cobar (1) population, 75% of the specimens were correctly classified, with the other 25% of the specimens being reclassified with the Cowell (K) population; 25% of the Condobolin (2) population was also reclassified with the Cowell (K) population.

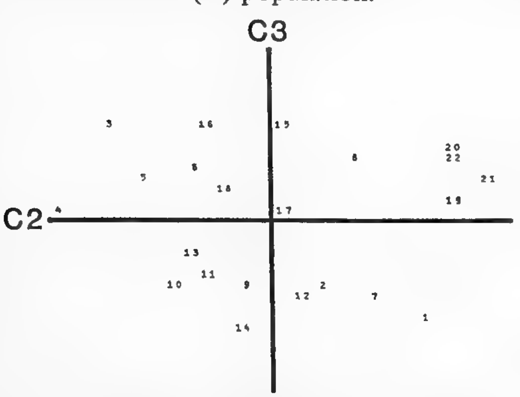


Fig. 11. Principal components plot (component 1 versus component 2) of the character set of *P. aspalathoides*. 1 = INTER: 2 = STHD: 3 = STGD; 4 = LL; 5 = LLW; 6 = LLWL; 7 = LHD; 8 = LGD; 9 = PL; 10 = BL; 11 = BLW; 12 = LKLP; 13 = KL; 14 = KLLT; 15 = KHDO; 16 = KGDO; 17 = KHDI; 18 = AAL; 19 = STHW; 20 = STHL; 21 = STBB; 22 = STMX. For details of characters refer Table 1.

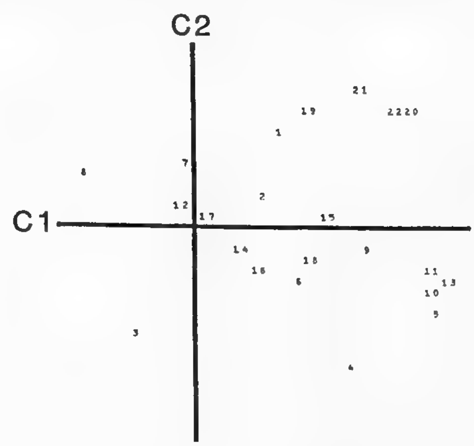


Fig. 12. Principal components plot (component 2 versus component 3) of the character set of *P. aspalathoides*. For details of characters refer Fig. 11 and Table 1.

The first four axes of the principal coordinates analysis accounted for only 31% of the total variation. Therefore, these ordinations provided a simplification of the data which is of limited value. The ordination on these axes produces relatively indistinct clusters. The Kangaroo Island populations are weakly distinct from the mainland populations on most axes (Fig. 14-T, U). Similarly, the Cobar (A), Condobolin (B), West Wyalong (C) and Rankin Springs (D) populations are weakly distinct. However overall, principal coordinates analysis did not provide a useful simplification of the data. Similar results were obtained using the Q-technique of principal component analysis. Furthermore, single-linkage, nearest-neighbour and furthest-neighbour phenograms, generated from the matrix of the Manhattan metric distances, provided little additional information and their complexity reduced their ability to provide a visual simplification of the data.

Therefore, since the morphological variation within *P. aspalathoides* is more or less continuous, a formal infraspecific classification is not proposed. This morphological variation is discussed in more detail in the 'Geographic Variation' chapter.

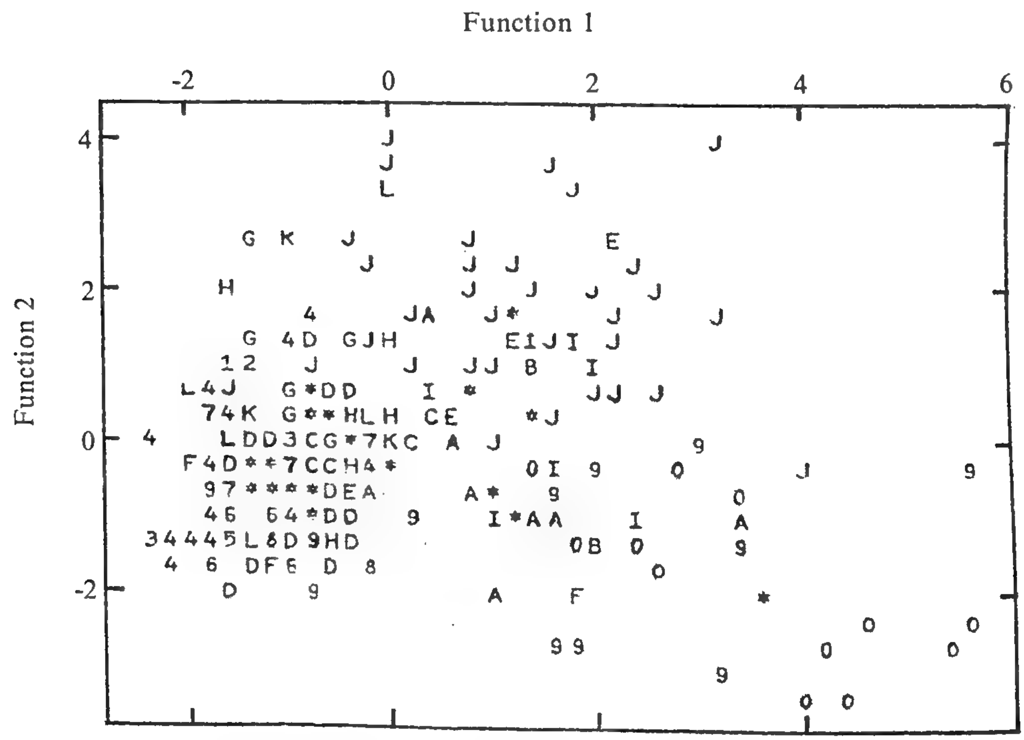


Fig. 13. Canonical variate scattergram (function 1 versus function 2) of *P. aspalathoides*. For details of taxa refer Table 8. 1 = 1; 2 = 2; 3 = 3; 4 = 4; 5 = 5; 6 = 6; 7 = 7; 8 = 8; 9 = 9; 0 = 10; A = 11; B = 12; C = 13; D = 14; E = 15; F = 16; G = 17; H = 18; I = 19; J = 20; K = 21; L = 22; * = group centroid.

Numerical analysis of the *Prostanthera calycina—P. microphylla—P. serpyllifolia* complex

Prostanthera serpyllifolia and *P. calycina* are confined to South Australia, whereas *P. microphylla* occurs in New South Wales, Victoria, South Australia and southern Western Australia. The Victorian populations of the latter species are very homogeneous,

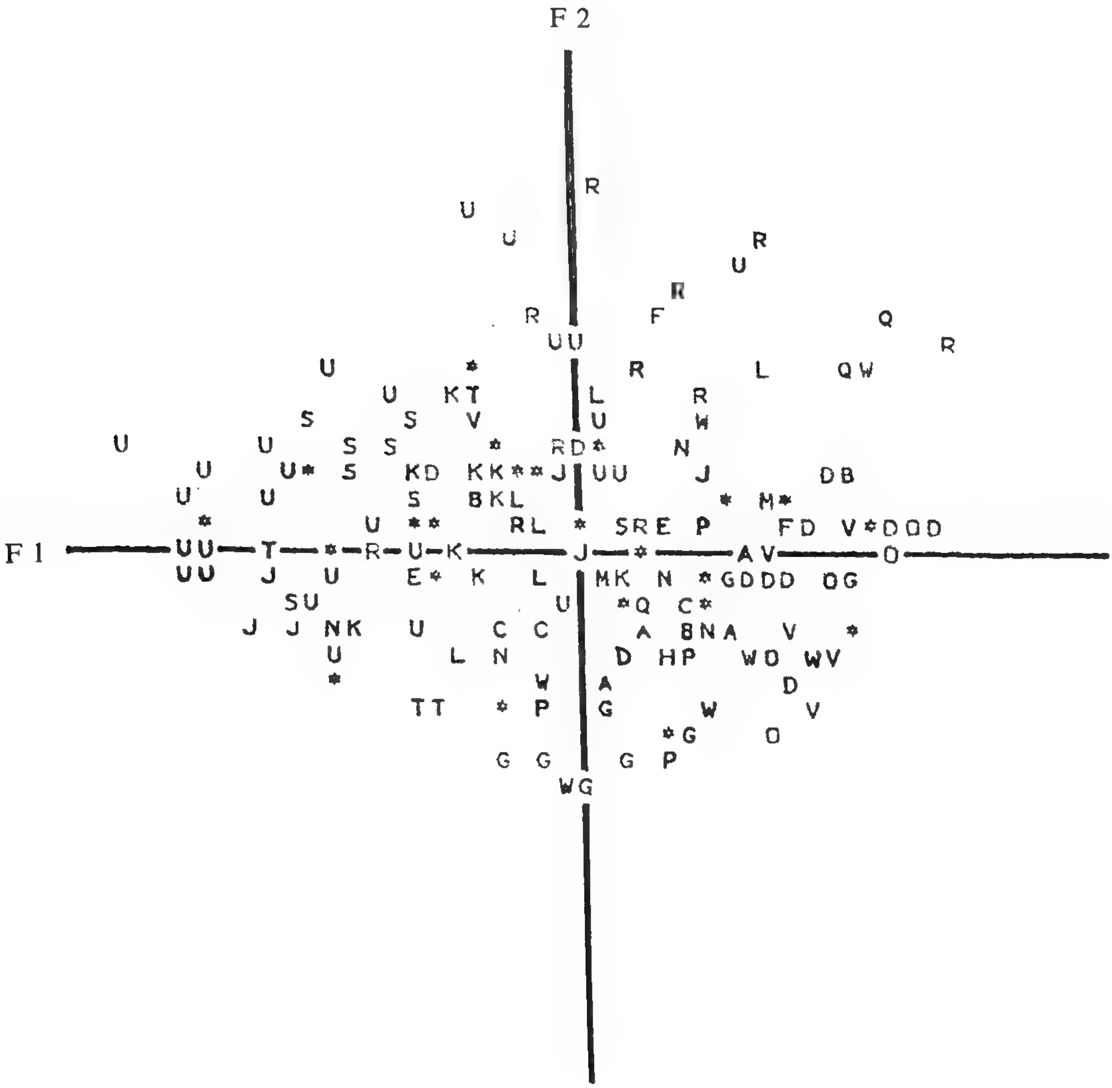


Fig. 14. Principal coordinate plot (function 1 versus function 2) of the populations of *P. aspalathoides*. A = Cobar; B = Condobolin; C = West Wyalong; D = Rankin Springs; E = Barellan; F = Balranald; G = Bendigo; H = Wyperfeld; J = Kiata; K = Little Desert; L = Bordertown; M = Scorpion Spring; N = Billiatt; O = Overland Corner; P = Walker Flat; Q = Coomandook; R = Braendler's Scrub; S = Goolwa; T = American River; U = Kingscote; V = Cowell; W = Whyalla; * = two or more individuals from different groups, if from same group then group symbol printed.

all having the calyx hairy on the outer surface, plus an anther appendage. In New South Wales, in the Murray Lands of South Australia, and in Western Australia, the populations are less homogeneous, but are still readily distinguishable from closely related taxa. However, *P. microphylla* from Eyre Peninsula (South Australia) is extremely variable and is frequently difficult to distinguish from *P. serpyllifolia*, and to a lesser extent, from *P. calycina*. The Moonta population (on Yorke Peninsula, South Australia) is typical of much of the collections (of *P. microphylla*) from New South Wales and Victoria. Therefore, this population was included in this study so that a comparison between the Eyre Peninsula populations and those of the eastern States could be made. The Kangaroo Island populations (5-8) were included so as to facilitate an evaluation of the distinctness of these populations from the mainland specimens. 156 specimens from 14 populations were analysed (Fig. 27). The number of specimens in each population and the localities of each are listed in Table 10.

The nearest-neighbour phenogram (based on all characters except KHDI) generated from the matrix of the Manhattan metric distances is presented in figure 15 (for details of collection refer Table 8). The complexity of this phenogram reduces its ability to provide a visual simplification of the data. However, it does provide some information on the infra-structure of this complex.

The various populations represented in this phenogram (Fig. 15) are clearly heterogeneous (*cf.* the duplicates of *Eichler 15172*, and the population collections of *Conn 684*, *1073*, *1077-1079*, *1089-1091*, *1093*, *1096 & 1097*). However, the Stenhouse Bay population is relatively distinct from the other populations even though there is a close relationship with several of the Port Lincoln specimens. The distinctiveness of this population is also suggested in figures 8 & 9. The Stenhouse Bay population is composed of individuals which are glabrous or very sparsely hairy with a very high glandular density on most organs. They also have more or less shiny leaves which are often thickened. However, this form is regarded as environmentally induced (p. 256). The distinctiveness of the genotype is unknown; however when additional collections (not used in the numerical analyses) from further inland are considered, these collections tend to be intermediate between the more typical *P. serpyllifolia* ssp. *serpyllifolia* and this local form. Therefore, the Stenhouse Bay form is not given formal taxonomic status.

The only other populations which are relatively distinct from the other specimens are the Venus Bay and Streaky Bay populations (Fig. 15, specimens 151-156). The specimens from these two populations belong to *P. calycina*. They tend to be very hairy on the branches and have relatively large calyces. The hairs are simple, stiff, straight and appressed such that the hair apex is directed towards the distal part of the relevant organ (Fig. 60C). When additional specimens (not included in the numerical analyses) are considered, these specimens remain distinct from *P. serpyllifolia*. *P. calycina* grows under a different set of environmental factors to that of *P. serpyllifolia* (pp. 257-262). Hence it is not unexpected that there is also a different phenotypic response to these factors. However, this taxon appears to be genetically distinct since there are a few collections of *P. serpyllifolia* occurring sympatrically with *P. calycina* at Venus Bay. Furthermore, cultivated material of this species at the Burrendong Arboretum (N.S.W.) (*Conn 793*) has retained its phenotypic distinctness from *P. serpyllifolia*. Therefore, *P. calycina* is maintained as a distinct species.

Although certain individual specimens are very distinctive (Fig. 15) the overall homogeneity of the morphological variation of the specimens (also refer Figs 8-10) suggest that *P. microphylla* cannot be maintained as a distinct species from *P. serpyllifolia*. However, this taxon can usefully be recongized as a subspecies of *P. serpyllifolia*, even though some specimens appear intermediate between the two subspecies. The key differences between these subspecies are summarized in the key to the subspecies of *P. serpyllifolia* (p. 293).

Fig. 15. Nearest-neighbour phenogram (based on all characters except KHDI) generated from the Manhattan distance matrix of 156 specimens of the *Prostanthera calycina*—*P. microphylla*—*P. serpyllifolia* complex. Population numbers are: 1 = Kimba; 2 = Arno Bay; 3 = Lock; 4 = Moonta; 5 = Cape Borda; 6 = Kelly Hill Cave; 7 = Mt Taylor; 8 = Cape Cassini; 9 = Port Lincoln; 10 = Mt Greenly; 11 = Stenhouse Bay (Innes National Park); 12 = Hincks Conservation Park; 13 = Venus Bay; 14 = Streaky Bay. The numbers directly above the phenogram refer to the specimens (refer Table 8 for details of collectors and collection numbers).

Table 8. Details of the 156 collections used in the numerical analyses of the *P. calycina—P. microphylla—P. serpyllifolia* complex.

1. Hill 652	53. Conn 1077e	105. Copley 4424
2. Whibley 279	54. Conn 1080	106. Lothian 2638
3. Eichler 19193	55. Conn 1078a	107. Blaylock 70
4. Canning CBG 23620	56. Conn 1078b	108. Copley 4619
5. Phillips CBG 23621	57. Conn 1078c	109. Jackson 2641
6. Orchard 2138	58. Conn 1079a	110. Blaylock 1092
7. Beauglehole 17575	59. Conn 1079b	111. Carrick 3907
8. Rohrlach 625	60. Conn 1079c	112. Carrick 3913
9. Orchard 2138	61. Eichler 15172 (UC)	113. Carrick 3904
10. Rohrlach 158	62. Eichler 15172 (AD)	114. Carrick 3905
11. Rosier 59	63. Conn 1089a	115. Carrick 3903
12. Hilton s.n., 27.viii.1955	64. Conn 1089b	116. Carrick 3902
13. Caulfield 236	65. Conn 1089c	117. Carrick 3901
14. Wilson 236	66. Conn 1090a	118. Carrick 3906
15. Tindale 463	67. Conn 1090b	119. Carrick 3908
16. Ising s.n., 27.viii.1935	68. Conn 1090c	120. Carrick 3909
17. Alcock 631	69. Conn 1091a	121. Carrick 3910
18. Whibley 1992	70. Conn 1091b	122. Carrick 3911A
19. Tindale 463	71. Conn 1091c	123. Carrick 3911B
20. Eichler 19171	72. Jackson 376	124. Carrick 3912
21. Whibley 7435	73. Eichler 15490	125. Copley 4425
22. Alcock 632	74. Eichler 18538	126. Hill 1080
23. Ising s.n., 27.viii.1935	75. Conn 1093a	127. Hill 1078
24. Barker 3639A	76. Conn 1093b	128. Copley 4423
25. Barker 3639B	77. Conn 1093c	129. Blaylock 1124
26. Barker 3639C	78. Conn 1096a	130. Heyligers 80127
27. Phillips CBG 23546	79. Conn 1096b	131. Smith 779
28. Phillips CBG 23846	80. Conn 1096c	132. Kraehenbuehl 864
29. Puckridge s.n., anno. 1962	81. Conn 1097a	133. Alcock 4539
30. Tindale 590	82. Conn 1097b	134. Spooner 6171
31. Phillips CBG 23783	83. Conn 1097c	135. Copley 4897
32. Gill 152	84. Jackson 852	136. Cleland s.n., 12.viii.1964
33. Beythieu 92	85. Conn 1073a	137. Symon 6158
34. Beythieu 91	86. Conn 1073b	138. Wheeler 801
35. Phillips CBG 23839	87. Conn 1073c	139. Alcock 2202
36. Donner 1871	88. Conn 1073d	140. Cleland s.n., 17.ix.1966
37. Copley 4091	89. Conn 1073e	141. Wheeler 748
38. Copley 770	90. Browne s.n. (MEL)	142. Symon 6319
39. Phillips CBG 31378	91. Specht 2706	143. Symon 6192
40. Copley 2285	92. Wilson 410	144. Symon 6320
41. Tepper s.n., anno. 1874	93. Wilson 411	145. Symon 6426
42. Eichler 15172 (NSW)	94. Anon. (AD966032930)	146. Alcock 2351
43. Eichler 15172 (MEL)	95. Whibley 1961	147. Alcock 1568
44. Cleland s.n., 2.ii.1948	96. Ising s.n., 17.x.1936	148. Cleland s.n., 10.vi.1965
45. Kirkpatrick s.n., -.xii.1968	97. Conn 684A	149. Specht 2067
46. Phillips s.n., 28.ix.1965	98. Conn 684B	150. Wheeler 888
47. Eichler 15172 (E)	99. Conn 684C	151. Warburton s.n. (MEL)
48. Wheeler 1308	100. Hill 1079	152. Willis s.n., 26.viii.1947
49. Conn 1077a	101. Copley 4519	153. Dennis 170
50. Conn 1077b	102. Copley 4520	154. Weber 6210
51. Conn 1077c	103. Weber 4254	155. Wrigley CBG 36640
52. Conn 1077d	104. Weber 4342	156. Copley 4858

Numerical analysis of the *Prostanthera laricoides* complex

Canonical variate analysis of the 8 populations of the *P. laricoides* complex (Fig. 34) produced distinct clustering on the first two functions (Fig. 16). Populations 1, possibly 3, 4, 7 and 8 are distinct from each other, whereas populations 2, 5 and 6 appear to represent a single group. On the first and third functions, populations 2, 5 and 6 were tightly clustered, whereas population 3 was distinct from the former group and less distinct from population 4. The nearest-neighbour phenogram of the canonical variate distances between group centroids (based on the square root of Mahalanobis' D^2) (Fig. 8) also emphasizes the distinctness of the above groups. It also suggests a close relationship between the Campion, Southern Cross and Mt Churchman populations (F, H & I [in Fig. 34 = 2, 5 & 6, respectively]). In the remaining discussion of this complex, I have included the taxonomic conclusions with the relevant population(s) when these are discussed, so that cross-referencing from the 'Systematic Treatment' to this section will be easier.

The nearest-neighbour phenogram of the individual specimens (based on a matrix of Manhattan metric distances of all characters except KHDI) (Fig. 17) allows for a more detailed evaluation of the infrastructure of these taxa than is possible using group centroids (Fig. 8). Populations 1 (*P. laricoides*), 3 and 4 (*P. incurvata*), and 8 (*P. patens*) are distinct. Populations 2, 5 and 6 (*P. semiteres*) plus population 7 (*P. pedicellata*), represent a closely related, although somewhat heterogeneous group.

The first three axes of the principal coordinate analysis provide a useful simplification of the data because they account for 50.87% of the total variation. The ordination on these axes produces relatively distinct clusters. Population 8 (*P. patens*) is very distinct on all functions (e.g. function 1 versus 2 [Fig. 18] and functions 2 versus 3 [Fig. 19]). Populations 1,

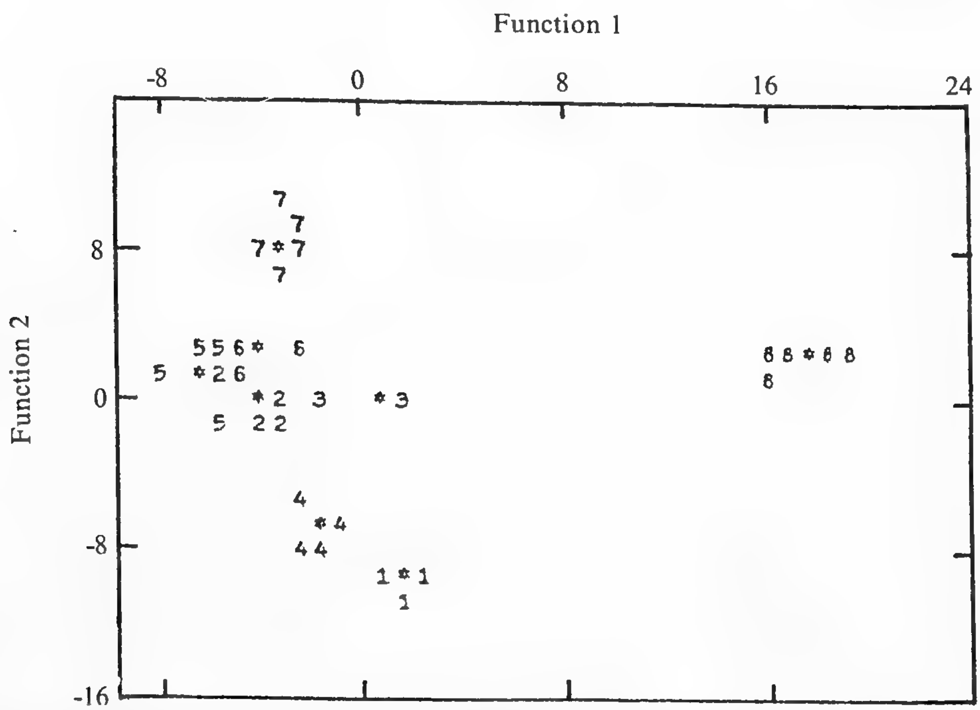


Fig. 16. Canonical variate scattergram (function 1 versus function 2) of the 8 populations of the *P. laricoides* complex. For details of the populations refer Fig. 34 and Table 11.

3 and 4 form a distinct group on functions 1 versus 2 (Fig. 19), with *P. laricoides* (1) clearly distinct from *P. incurvata* (3 & 4) on functions 1 versus 2 (Fig. 18) and 2 versus 3 (Fig. 19). Populations 2, 5-7 form a single separate cluster on the first three functions (Figs 18 & 19). Populations 2 and 5 (*P. semiteres* ssp. *semiteres*) are indistinct on all functions. Populations 6 (*P. semiteres* ssp. *intricata*) is distinct on the first three functions (Figs 18 & 19), but indistinct on most other functions. Although population 7 (*P. pedicellata*) is closely related to population 6 (*P. semiteres* ssp. *intricata*), the ordination maintains the former as a distinct group (Figs 18 & 19).

I have recognized five species in this complex (*viz. P. incurvata, P. laricoides, P. patens, P. pedicellata,* and *P. semiteres*). The outer surface of the calyx is glabrous in *P. incurvata* and *P. semiteres*, whereas the other species are normally hairy on the outer surface of the calyx. *P. pedicellata* has a long pedicel (7-13 mm long) and lacks an anther appendage, whereas *P. patens* and *P. laricoides* have pedicels less than 3.5 mm long and they have an anther appendage. These latter two species can be distinguished from each other by *P. patens* having small leaves (less than 2 mm long), whereas *P. laricoides* has leaves at least 10 mm long. *P. incurvata* has hairy branches (rarely glabrous) with pedicels up to 2 mm long and usually incurved leaves which distinguish it from *P. semiteres. P. semiteres* has glabrous branches (rarely with an occasional hair) with pedicels 3-15 mm long and more or less straight leaves.

With the exception of *P. patens*, the *P. laricoides* complex is made up of closely related species. *P. patens* has its closest affinities with *P. serpyllifolia*, whereas the affinities of the remaining species appear to be with *P. aspalathoides.*

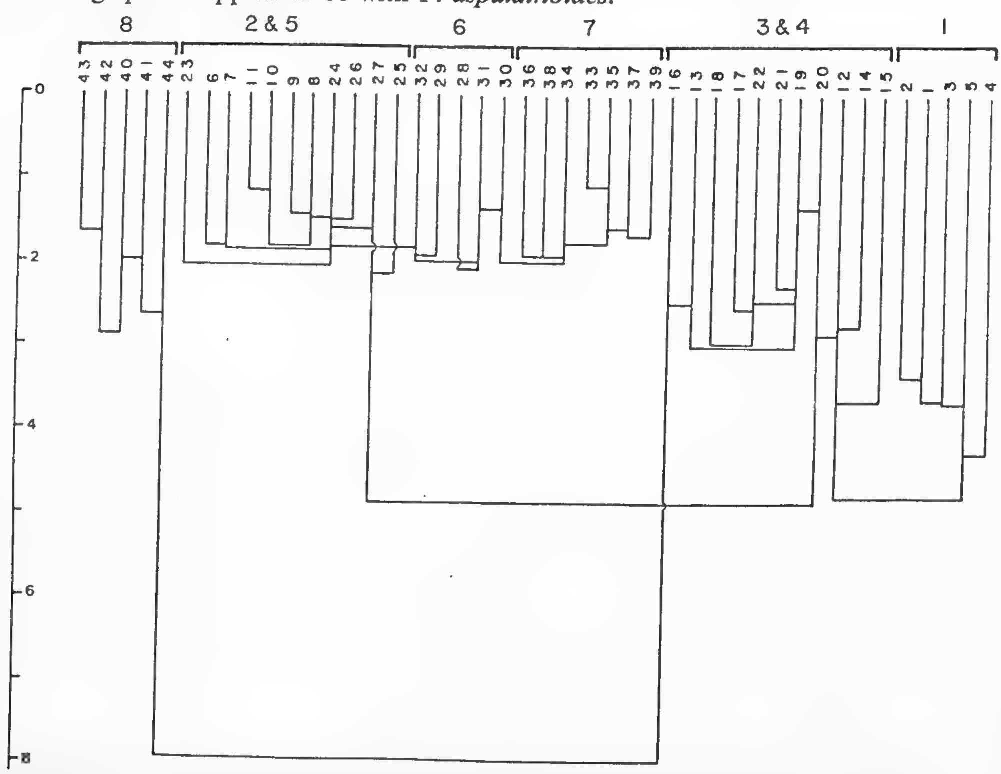


Fig. 17. Nearest-neighbour phenogram generated from the Manhattan distance matrix of the 44 specimens of the *P. laricoides* complex (based on all characters except KHDI). Population numbers (as used in Table 11 and Fig. 34 are given above the brackets. The numbers directly above the phenogram refer to the specimens (refer Table 12 for details of collectors and collection numbers).

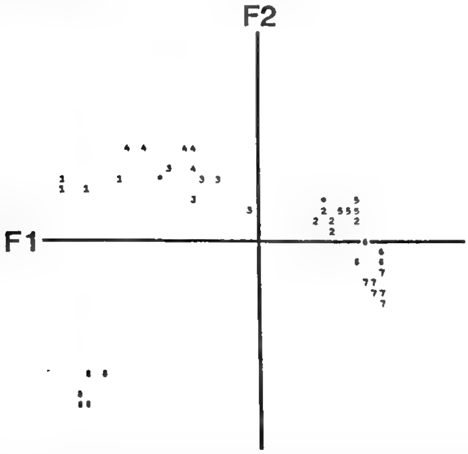


Fig. 18. Principal coordinate plot (function 1 versus function 2) of the populations in the *P. laricoides* complex. 1 = Cundeelee; 2 = Campion; 3 = Lake Cowan; 4 = Kalgoorlie; 5 = Southern Cross; 6 = Mt Churchman; 7 = Pindar; 8 = Paynes Find; * = Two or more individuals from different groups, if from same group then group symbol printed. For further details of populations refer Fig. 34 and Table 11.

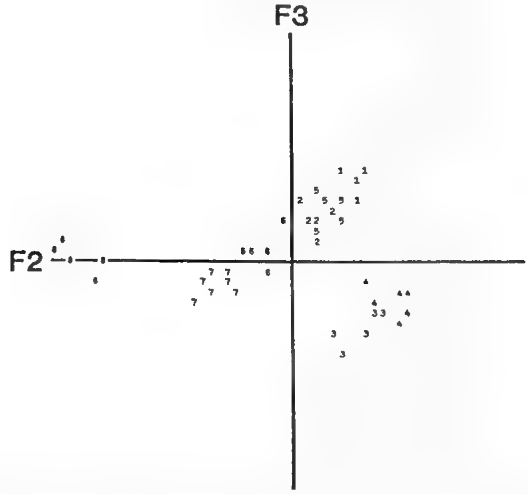


Fig. 19. Principal coordinate plot (function 2 versus function 3) of the populations in the *P. laricoides* complex. 1 = Cundeelee; 2 = Campion; 3 = Lake Cowan; 4 = Kalgoorlie; 5 = Southern Cross; 6 = Mt Churchman; 7 = Pindar; 8 = Paynes Find; If two or more individuals from the same group have the same coordinates then group symbol printed. For further details of populations refer Fig. 34 and Table 11.

Geographic variation

Geographic variation is the 'pattern of variation present within a species over its entire range' (Whiffin 1978). The detailed analysis of geographic variation often provides useful information, especially amongst closely related taxa, on the pattern of variation present, on possible modes of speciation, and on the historical biogeography and lines of migration of the taxa.

Geographic variation is the resultant complex response of many characters to a variety of interdependent environmental and genetical factors. Hence it is a multidimensional process (Fisher 1968). The factors determining and limiting the pattern of distribution of a taxon, within its range, are quite different from those factors which control the extent of its total geographic range. For example, certain ecological factors result in a taxon having a complex mosaic pattern of variation within its total range. Since geographic variation is complex, any study of such variation may benefit by the use of various numerical and statistical procedures to simplify and assist in the visualization of the overall pattern of variation.

Several computer programs, which have been variously modified (written in Fortran 77 [version 5] {Meissner & Organick 1980} for use on the CDC Cyber 173 {CDC. 1981, Fortran version 5 Reference manual, Publ. no. 6048130}, at the University of Adelaide) were used to perform the various analyses (for details also refer Whiffin 1978, 1982a). Initially, the original 23 characters were standardized by range ($0 \leq$ character states ≤ 1) so as to minimise the effect of large, isolated ('outlying') values. Although not presented here, standardization by standard deviation appeared to be equally useful. The population means for each character were computed and weighted by the *F*-1 value (Adams 1975). Since the specimens were divided *a priori* into groups (populations), the characters were weighted according to their utility for distinguishing among the groups. Those characters which had the most significant between-group variation carried the most weight in the subsequent analyses. All characters with *F* values less than 1 (at the 0.01 level) were rejected and were not used in subsequent analyses. The data was also subjected to the Student-Newman-

Keuls (SNK) multiple range procedure (Adams 1969, 1970b, 1972a; Sokal 1965; Sokal & Rohlf 1969) (using program SNK) to determine which population means were significantly different (at the 0.01 level). The population means of those characters that were significantly different between populations (at the 0.01 level) in both the *F* test and the SNK test were contoured using surface trend analysis (Adams 1970b, 1970c, 1972a, 1974; Krumbein 1962; Marcus & Vandermeir 1966; Sokal 1965; Turner 1970; Whiffin 1978) (using program CONTRS). Although valuable information concerning geographic variation can be obtained by the consideration of each character separately, it is in general, more useful and more valid to consider all characters (which are significant for both the *F* test and the SNK test) simultaneously (Whiffin 1978). The multivariate approach is more valid because geographic variation is generally the result of many environmental and genetical factors acting upon the whole genotype. Differential systematics was used (Adams 1970c, 1972a; Hagmeir 1958, Womble 1951). This a multivariate method which maps the composite differential produced by Adams (1970c). Differential systematics gives an indication of the total trend of several characters simultaneously. The program DIFSYS (originally written by Adams 1969, 1970c) was used to produce the differential systematics, with the differentials for each character weighted according to their *F* ratios.

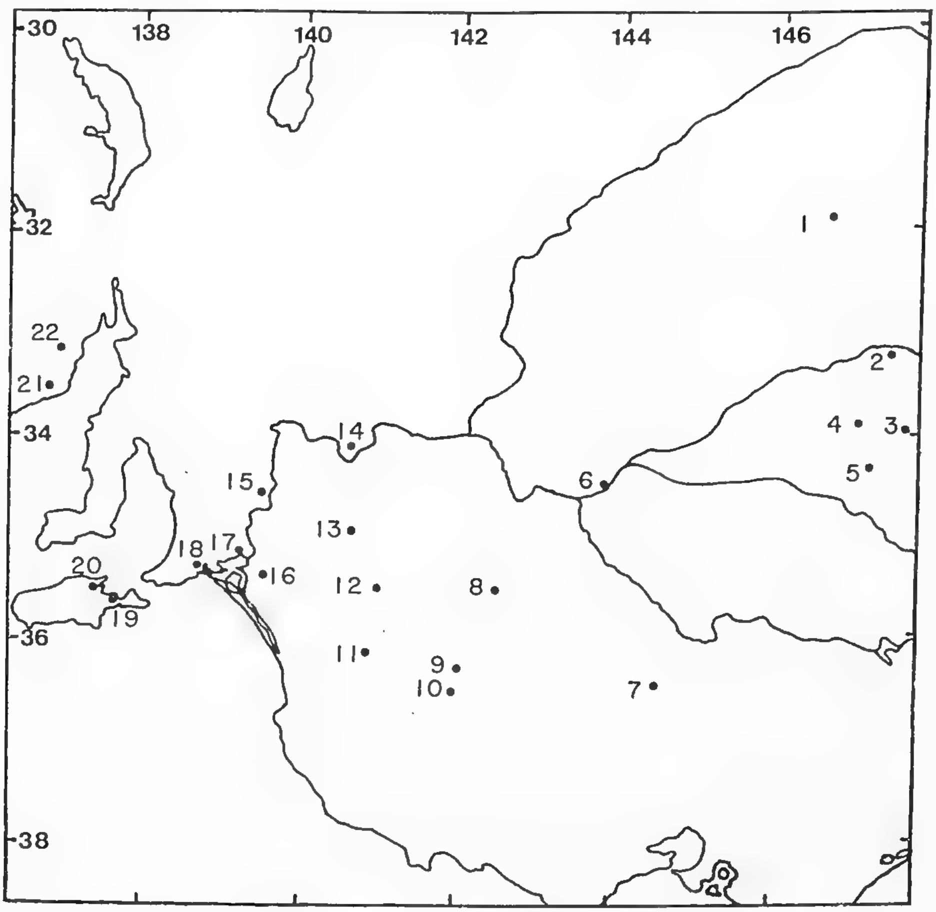


Fig. 20. Locality details of the 22 populations of *P. aspalathoides* used for morphological variation studies. For further details of populations refer Table 9.

Morphological variation in *Prostanthera aspalathoides*

P. aspalathoides occurs in New South Wales, Victoria and South Australia (Fig. 63). The single collection from St. George, Queensland (*R. Jordan s.n.*) was not included in this study because one collection could not be expected to represent satisfactorily the morphological structure of the St George population: 190 specimens from twenty-two populations were analysed (Fig. 20) (refer p. 211 for details of general procedure followed). For further details of these populations refer Table 9.

Of the original 23 characters, 16 showed both a significant *F*-test and a significant SNK test (both at the 0.01 level). Each of these 16 characters was contour-mapped (using program CONTRS). These contour maps show the major regional trends in population means for the characters presented (Whiffin 1978).

Based on the pattern of variation, it is possible to group the contour maps of the characters subjectively into a number of main types. Examples of contour maps of characters in these main types are provided in figures 21-25. A summary of the SNK test (for the relevant character) is provided under each contour map. Any two populations whose means are not underscored by the same line are significantly different for that character, but any two underscored by the same line are not highly significantly different (Sokal & Rinkel 1963; Sokal & Rohlf 1969; Adams 1970c). The populations are ranked in order of magnitude of means for each character. The population with the highest mean being recorded first (on left).

Table 9. Details of the 22 populations of *P. aspalathoides* used for morphological variation studies.

Population	Number of specimens/population
NEW SOUTH WALES	
1. Cobar	4
2. Condobolin	3
3. West Wyalong	7
4. Rankin Springs	15
5. Barellan	3
6. Balranald	7
VICTORIA	
7. Bendigo (Whipstick Mallee)	9
8. Wyperfeld National Park	4
9. Kiata	6
10. Little Desert (SE corner)	10
SOUTH AUSTRALIA	
11. Bordertown	10
12. Scorpion Springs National Park	3
13. Billiatt National Park	6
14. Overland Corner	10
15. Walker Flat	5
16. Coomandook	5
17. Braendler's Scrub (Monarto South)	12
18. Goolwa	11
19. American River	7
20. Kingscote	35
21. Cowell	8
22. Whyalla	10

The most common type of pattern of geographic variation is exemplified by the three characters 1) LL—length of lamina (Fig. 21), 2) LPLL—length of petiole to length of lamina ratio (Fig. 22), 3) LP—length of pedicel (Fig. 23). In figure 21, the Kingscote (20) and Little Desert (10) populations have the longest lamina. The populations with slightly shorter lamina (but not significantly different—refer SNK result, Fig. 21), in decreasing order, are Kiata (9), Goolwa (18), American River (19), Balranald (6), Braendler's (17), Bordertown (11), W. Wyalong (3) and Scorpion Springs (12). The more northerly populations of Cobar (1), Condobolin (2), Overland Corner (14), Whyalla (22) and Cowell (21), plus the Bendigo population (7) have short lamina. A similar pattern is found with

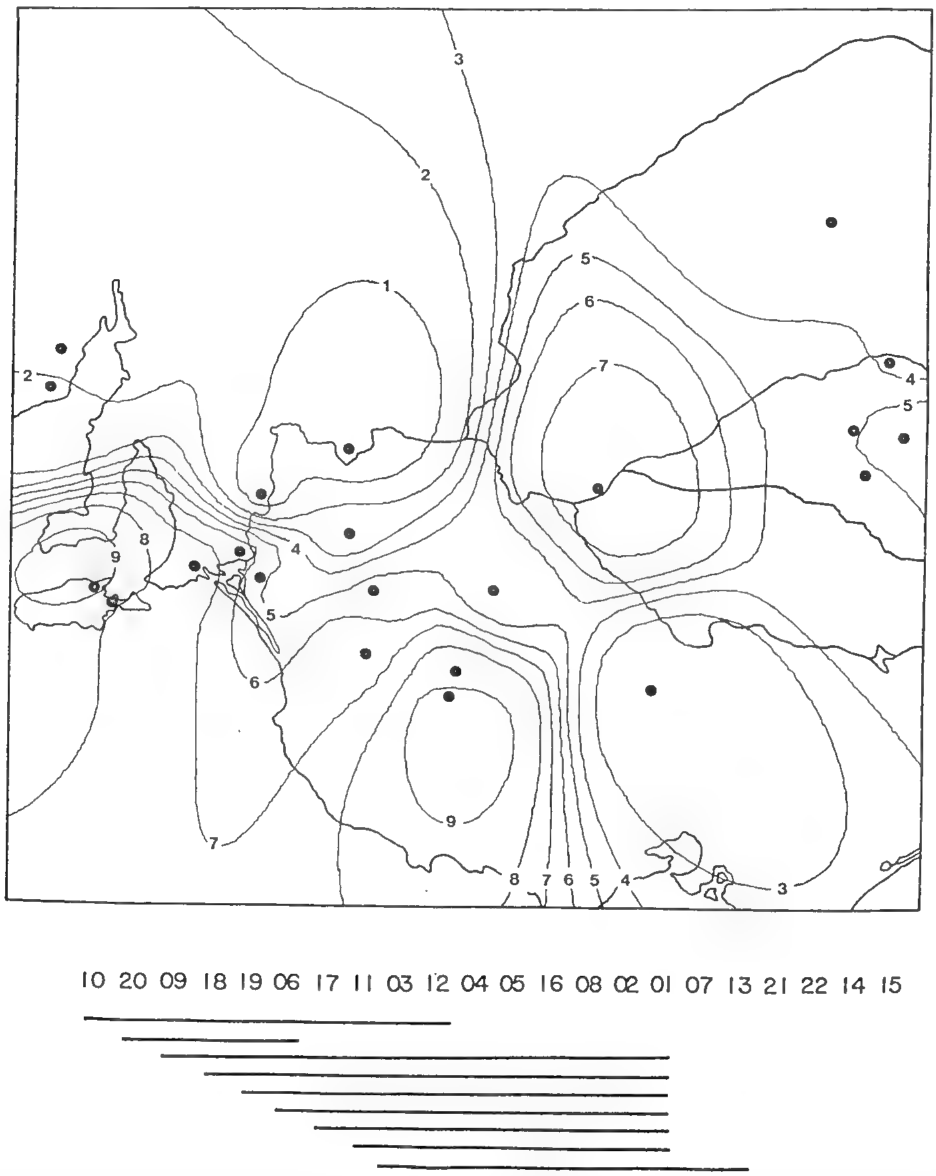


Fig. 21. Contour map (with summary of SNK test) of the lamina length (LL) in populations of *P. aspalathoides*. Contour symbols and values are: 1 = 0.27; 2 = 0.34; 3 = 0.41; 4 = 0.48; 5 = 0.55; 6 = 0.63; 7 = 0.70; 8 = 0.77; 9 = 0.84.

the length of petiole to length of lamina ratio—LPLL (Fig. 22). Those populations with leaves having the largest ratio (≃ to longest petiole) occur at Balranald (6) and Braendler's (17). As for length of lamina, the Bendigo (7); Overland Corner (14) (with the addition of Walker Flat—15), Cobar (1) and Condobolin (2) populations have the smallest ratio. The other populations (e.g. Goolwa—18, Kingscote—20, Coomandook—16, Kiata—9, American River—19, Bordertown—11, Scorpion Springs—12) have intermediate ratios.

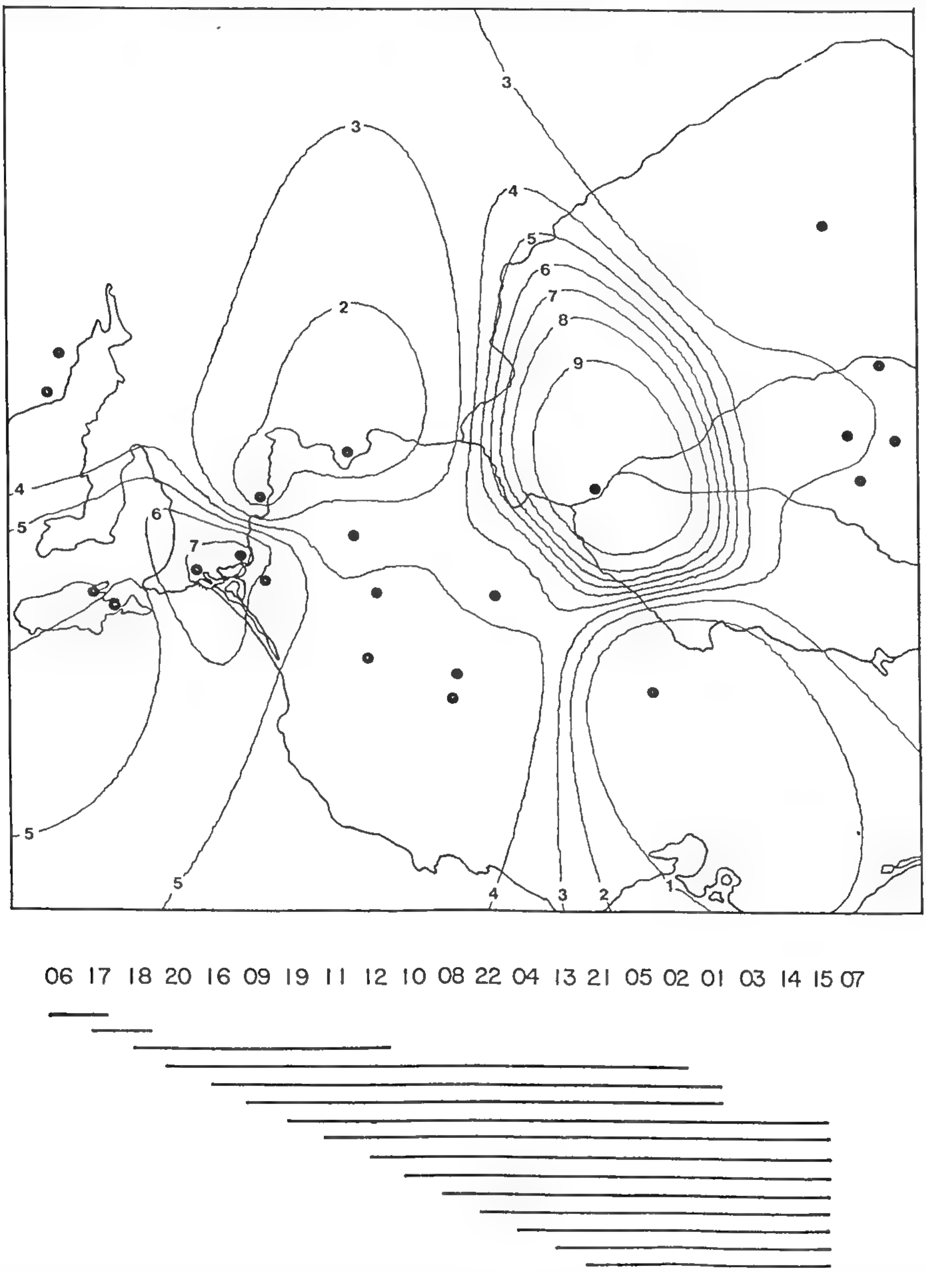
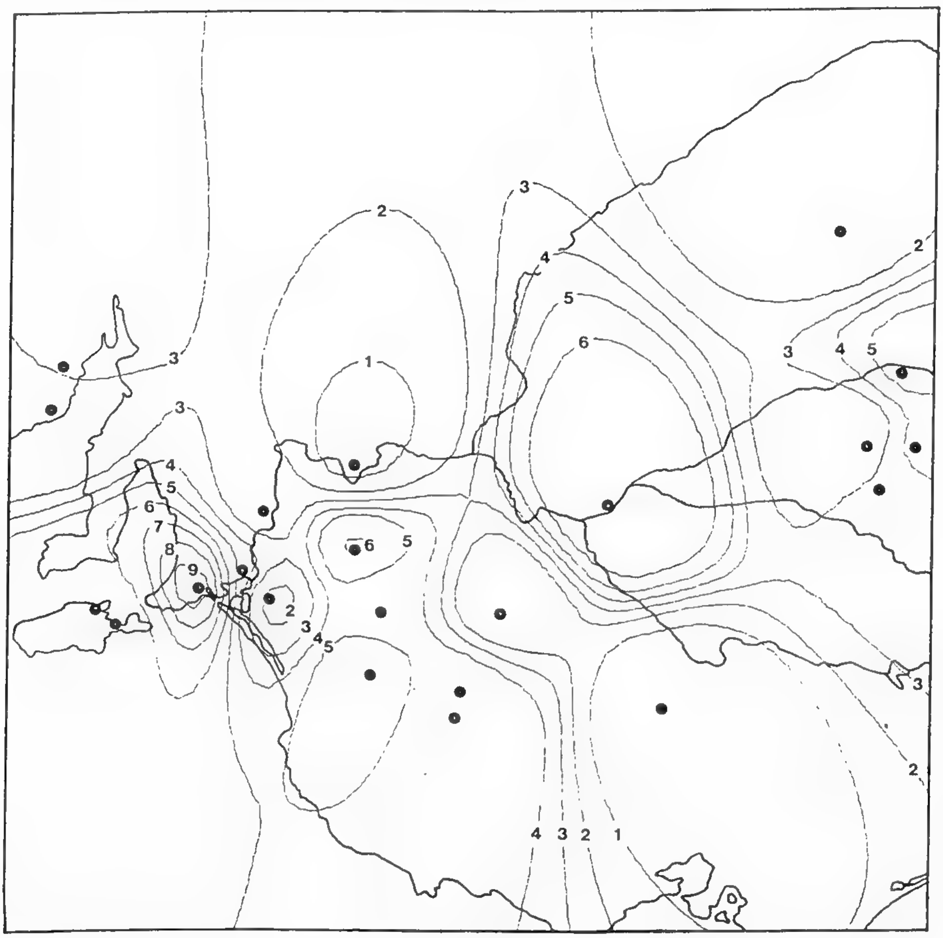


Fig. 22. Contour map (with a summary of SNK test) of the petiole length to lamina length ratio (LPLL) in populations of *P. aspalathoides*. Contour symbols and values are: 1 = 4.12; 2 = 4.78; 3 = 5.43; 4 = 6.09; 5 = 6.74; 6 = 7.40; 7 = 8.06; 8 = 8.71; 9 = 9.37.

Both of these characters (LL & LPLL) have high *F* values (15.81 & 15.68, respectively), while LP (length of pedicel), which shows a similar pattern of variation (Fig. 23), has an *F* value of 2.47. Therefore, the first two characters account for a more significant amount of the variation.

Another feature, of this most common type, is the frequent significant distinction between the Condobolin (2), West Wyalong (3), Rankin Springs (4), and Barellan (5) populations. Apart from the length of the pedicel—LP (Fig. 23) and the density of hairs on the leaf—LHD (Fig. 24), the density of hairs on the branches (STHD), length of prophylls (LB), length to width ratio of lamina (LLW), and density of glands on the branches (STGD) also distinguish between these populations.

The contour map of the density of hairs of the leaf—LHD (Fig. 24) produces a pattern of variation which is more or less opposite to that of the previous examples (i.e. LL, LPLL, LP). The Cowell (21), Condobolin (2), Overland Corner (14), Walker Flat (15) populations have leaves with high densities of hairs, whereas the Balranald (6) and Goolwa (18) populations have sparsely hairy or glabrous leaves.

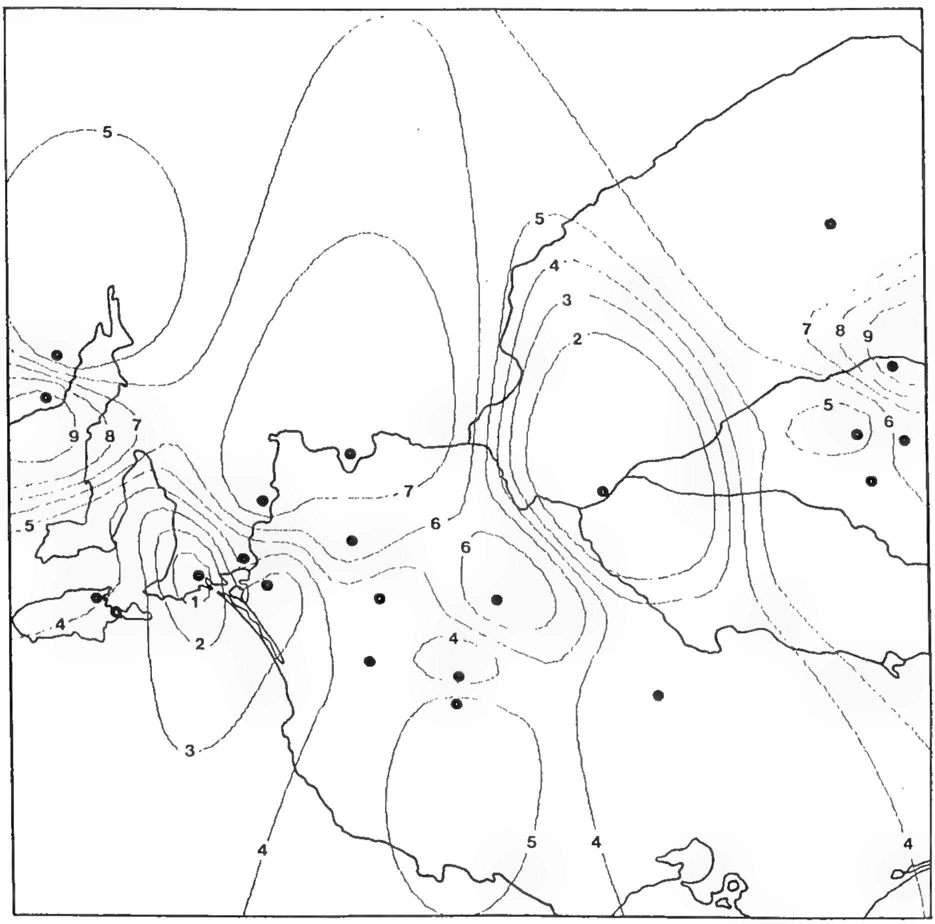


18 06 13 20 11 19 02 10 09 17 03 12 22 05 15 04 21 01 16 08 14 07

Fig. 23. Contour map (with summary of SNK test) of the pedicel length (LP) in populations of *P. aspalathoides*. Contour symbols and values are: 1 = 6.39; 2 = 6.62; 3 = 6.84; 4 = 7.06; 5 = 7.28; 6 = 7.51; 7 = 7.73; 8 = 7.95; 9 = 8.17.

The ratio of the length of the calyx to that of the calyx tube—KLLT (Fig. 25) produces a different pattern of variation. However, the northern populations and the Bendigo population have low means for this character, similar to the most common pattern. Furthermore, those populations in the south-west of this species distribution still have intermediate to high values, as found in most other characters. The main difference is that the pattern of variation is much simpler and more populations have lower means than usual.

The composite differential formed from the 16 significant characters is presented in figure 26. High contour levels indicate regions of rapid differentiation (change). The most rapid changes occur between the (i) Bendigo (7) and Balranald (6) populations, (ii) Bendigo and Little Desert (10)—Kiata (9) populations, (iii) Little Desert—Kiata and Wyperfeld (8) populations, (iv) Kangaroo Island (19 & 20) and the mainland (18, 21 & 22) populations. There are also regions of change, however to a lesser extent, among the south-western populations (11-18).



21 02 14 15 13 03 08 10 01 05 17 20 12 04 11 22 07 19 09 16 06 18

Fig. 24. Contour map (with summary of SNK test) of the density of leaf hairs (LHD) in populations of *P. aspalathoides*. Contour symbols and values are: 1 = 2.21; 2 = 2.31; 3 = 2.41; 4 = 2.51; 5 = 2.61; 6 = 2.72; 7 = 2.82; 8 = 2.92; 9 = 3.02.

Although the pattern of geographic variation presented (Fig. 26) is complex, this only represents a simplification of the actual pattern. Therefore, any explanation of this pattern can only be speculative. However, the main features of figure 26 (in conjunction with the univariate surface trend analysis contour maps) suggest at least one explanation for the pattern observed.

The northern populations (1, 14, 21 & 22) are phenetically homogenous and are distinct, collectively, from the more southerly populations (with the exception of the Bendigo population). These populations (with short, more or less sessile leaves, moderately hairy stems, relatively short pedicels, small calyx lobes, and other character states in common) occur in the Arid Moisture region (Gentilli 1972), which represents a climatic extremity within the distribution of this species.

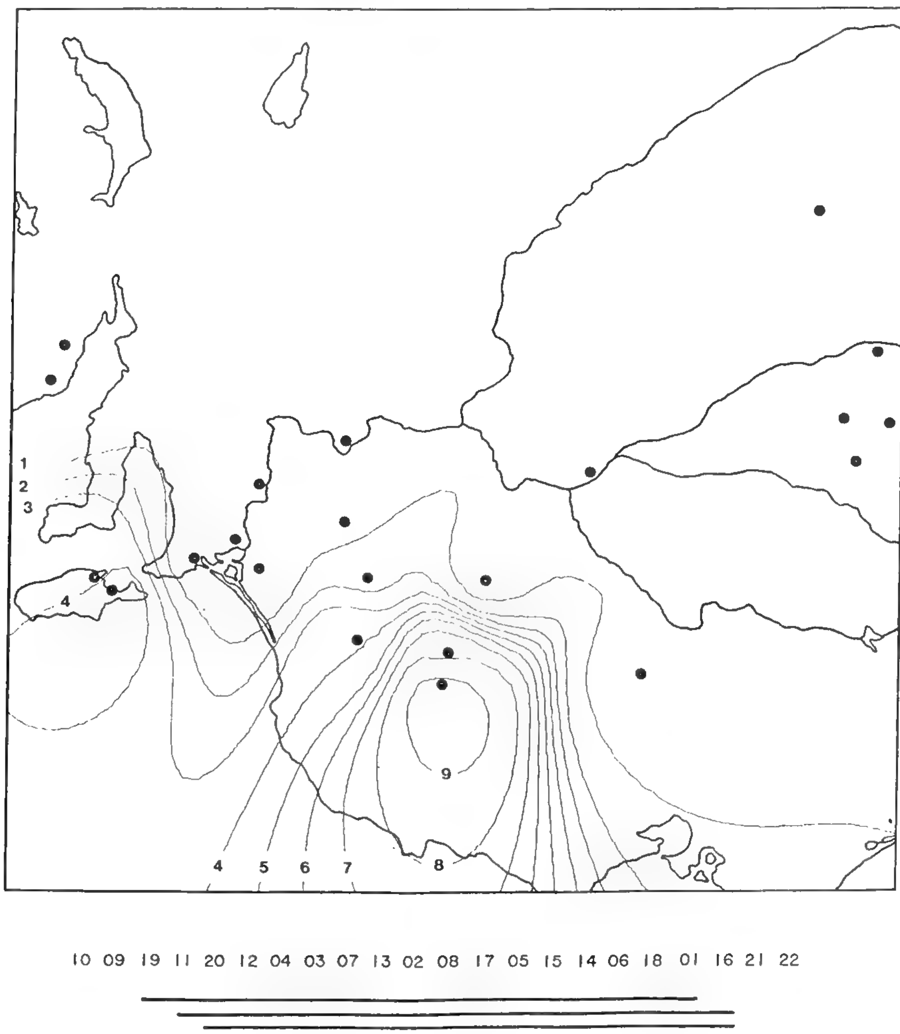


Fig. 25. Contour map (with summary of SNK test) of the length of the calyx lobes to the length of the calyx tube (KLLT) in populations of *P. aspalathoides*. Contour symbols and values are: 1 = 3.20; 2 = 9.61; 3 = 16.01; 4 = 22.41; 5 = 28.82; 6 = 35.22; 7 = 41.63; 8 = 48.03; 9 = 54.43.

The southern central region of the distribution (populations 9-13, 16-18) is an area of complex differentiation, but to a lesser extent than the four major areas of differentiation discussed before (p. 251). Although a high level of homogeneity exists between the populations of this region, subtle differences do exist, but only on a very local scale. This region (SemiArid Moisture region—Gentilli 1972) appears to be climatically optimal for this species. A similar trend occurs in the Rankin Springs—West Wyalong region (populations 2-4). This latter region, occurring near the SemiArid and SubHumid Moisture regions (Gentilli 1972), is also climatically optimal for this species. The plants in these two regions tend to have larger leaves, frequently with a distinct petiole, longer pedicels, larger calyx lobes, and a number of other characters have similar character states throughout the two regions.

The Bendigo population (7) is relatively distinct (Fig. 26) from the other populations, for example, the leaves are significantly broader and the branches have significantly fewer glands than the northern populations (1, 14, 21, 22). However, a number of character states are very similar to those found in the northern populations (1, 14, 21, 22), for example, short more or less sessile leaves, short prophylls, short pedicels and small calyx lobes.

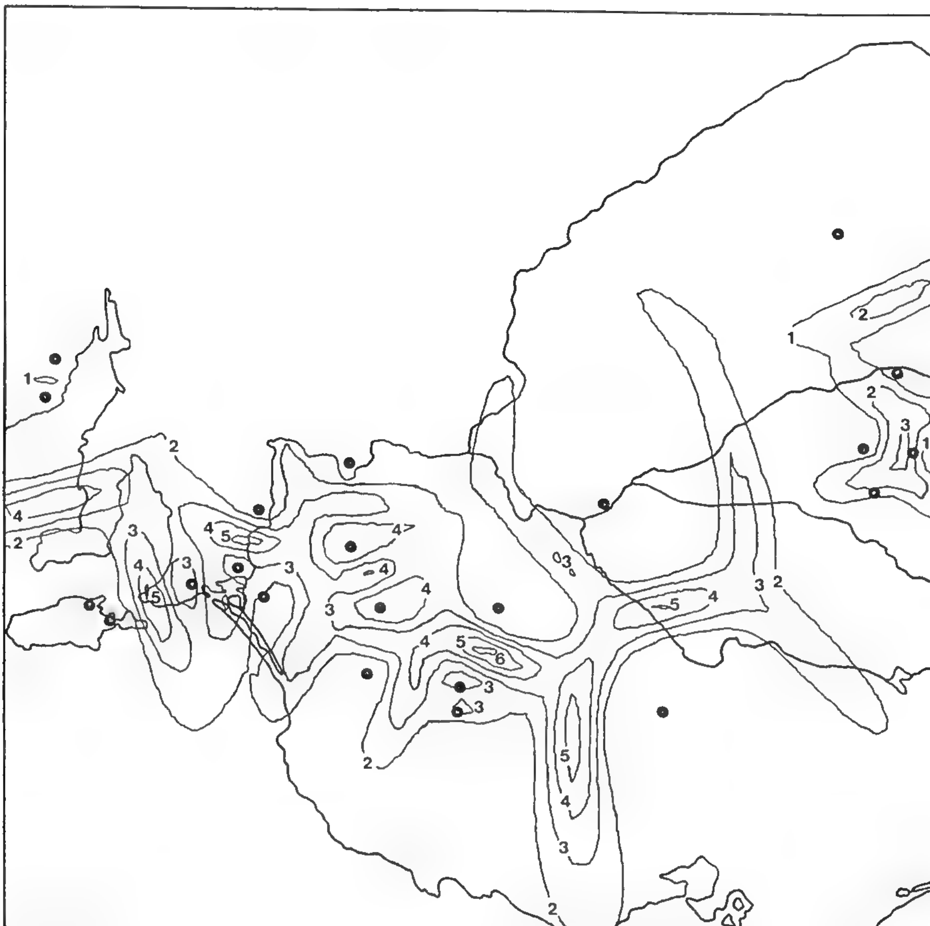


Fig. 26. The composite differential formed from 16 characters in populations of *P. aspalathoides*. Contour symbols and values are: 1 = 0.07; 2 = 0.12; 3 = 0.16; 4 = 0.21; 5 = 0.26; 6 = 0.31.

It is hypothesized that the Bendigo population occurs at a climatic extremity, as do the northern populations. Although the Bendigo population occurs near the boundary of the SemiArid and the SubHumid Moisture regions (Gentilli 1972), which in New South Wales represents reasonably good conditions for this species, the slightly higher rainfall and the longer, colder periods during winter may represent a climatic extreme. Since both the Bendigo and northern populations have small narrow leaves, a character (in sect. *Klanderia*) which appears to be easily modified by environmental factors, the climatic regime at Bendigo may be a very real distributional limit. Furthermore, the Bendigo population is relatively isolated by intensive agricultural practices. Therefore, the distinctness of this population will tend to be maintained, since interbreeding with other populations will probably be minimal.

The Kangaroo Island populations (19 & 20) are phenetically distinct from the mainland populations (Fig. 26). These populations have long narrow leaves, moderately large petiole length to lamina length ratios, and moderately long pedicels. Kangaroo Island has been isolated from the mainland for the last 9,300-9,500 years (Lampert 1981). Clearly, the Backstairs Passage and Investigator Strait represent significant barriers to interbreeding.

Morphological variation in *Prostanthera calycina—P. microphylla—P. serpyllifolia* complex

Although the techniques used to study geographic variation were developed to investigate the morphological variation within a species, the same techniques are here applied to an investigation of the morphological variation found within the *Prostanthera calycina—P. microphylla—P. serpyllifolia* complex for this region (Fig. 27). 156 specimens from fourteen populations were analysed (Fig. 27). For further details of the populations refer Table 10.

One common type of pattern of geographic variation is illustrated by the density of hairs on the outer surface of the calyx-KHDO (Fig. 28). The Moonta (4), Cape Borda (5), Kelly Hill Caves (6), and Mt Taylor (7) populations have specimens which have the outer surface of the calyx densely hairy. In this respect, these populations are comparable to the populations of Victoria and New South Wales. While the Cape Cassini (8), Stenhouse Bay (11), Port Lincoln (9), Mt Greenly (10), Venus Bay (13), and Streaky Bay (14) populations have specimens which have glabrous calyces or, at least very sparsely hairy. The remaining populations have a hair density, of the outer surface of the calyx, intermediate between the above extremes. A similar pattern occurs for the density of hairs on the leaves-LHD. In general, this type of pattern (refer, Fig. 28) has high values for the particular character, for Moonta (4) and the south-western Kangaroo Island (5-7) populations, with the lowest values occurring at the coastal populations 8-11, 13 & 14. Populations 1-3, & 12 have values intermediate between the two previous groups.

A slight modification of the previous pattern of geographic variation is illustrated by the position of the hairs on the branches—INTER (Fig. 29). As for the previous pattern, the Moonta (4) and the Kangaroo Island (5-7, and now, also 8) populations have hairs on all 'sides' of the branches. However, low values (≃ glabrous branches) are now restricted to the Stenhouse Bay (11) and Port Lincoln (9) populations. Those populations (1-3, 12) with intermediate values in the previous pattern, plus the Venus Bay (13) and Streaky Bay (14) populations, all have high values in this pattern. A similar trend, with some further subtle modifications, is found for the length of the anther appendage (AAL).

A third pattern of variation is exemplified by the lamina length—LL (Fig. 30), prophyll length (BL), and calyx length (KL). The mainland (9-11, 13 & 14) populations (with the exception of Arno Bay—2) have significantly high values. For example, these populations have long leaves (Fig. 30), long prophylls and large calyces. The Kangaroo Island

populations (5-8) and the other mainland populations have significantly low values. Hence, in the example illustrated in figure 30, these populations have short leaves.

The contour map of the pedicel length—PL (Fig. 31) produces a fourth major pattern of geographic variation which emphasizes the distinctness of the Mt Greenly (10) population. Frequently, the Port Lincoln (9) population is not significantly different from the Mt Greenly population (refer SNK results, Fig. 31). A similar pattern occurs for the lamina length to lamina width (LLW), and for the density of gland on the calyx (KGDO).

Although the above five patterns of variation are the most common, a number of other patterns are found. However, the characters with high *F* values show patterns of one of these five main types.

The composite differential formed from the 18 characters which showed both a significant *F*-test and a significant SNK test (both at the 0.01 level) is presented in figure 32. The most rapid changes occur between the (i) Kangaroo Island (5-8) and the mainland populations, (ii) Stenhouse Bay (11) and Moonta (4) populations, (iii) Stenhouse Bay and Eyre Peninsula (1-3, 9 & 10, 12-14) populations, whereas within Eyre Peninsula, the following populations show high levels of distinctness, (iv) Port Lincoln (9), (v) Mt Greenly (10), and (vi) Venus Bay and Streaky Bay collectively (13 & 14, respectively).

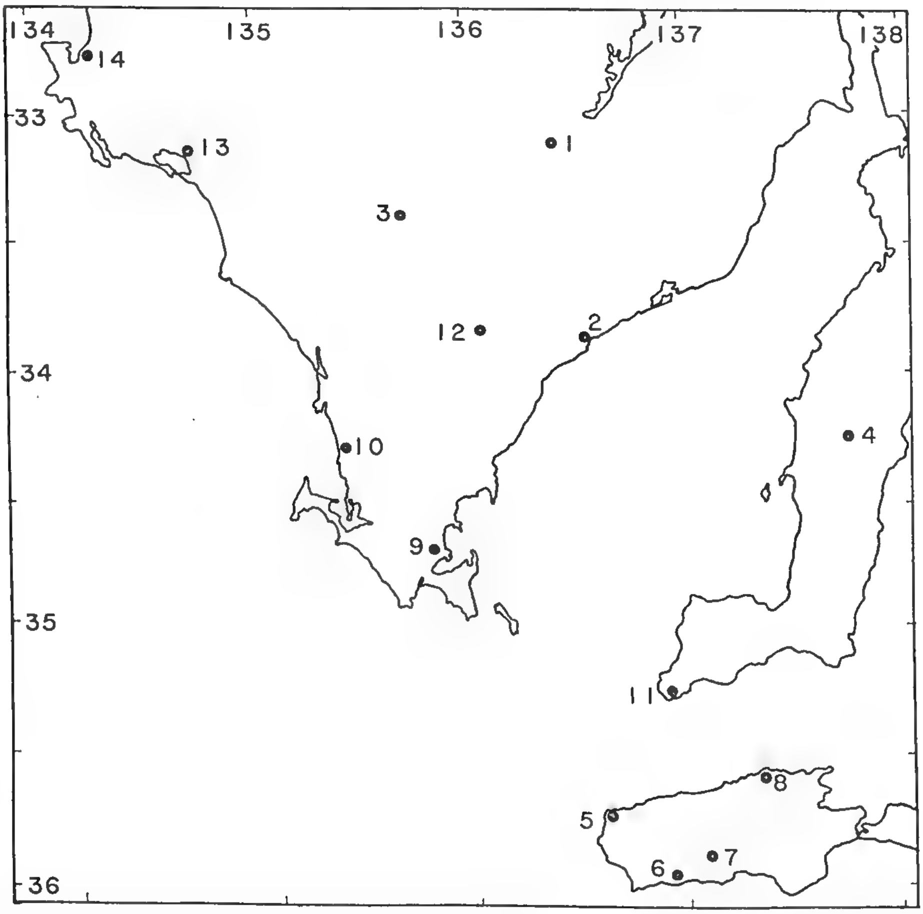


Fig. 27. Locality details of the 14 populations of the *P. calycina—P. microphylla—P. serpyllifolia* complex used for morphological variation studies. For further details of populations refer Table 10.

Table 10. Details of the 14 populations of the *P. calycina—P. microphylla—P. serpyllifolia* complex used for morphological variation studies.

Population	Number of specimens/population
SOUTH AUSTRALIA	
1. Kimba	14
2. Arno Bay	12
3. Lock	5
4. Moonta	10
5. Cape Borda	21
6. Kelly Hill Cave	15
7. Mt Taylor	7
8. Cape Cassini	5
9. Port Lincoln	7
10. Mt Greenly	3
11. Stenhouse Bay	36
12. Hincks Conservation Park	15
13. Venus Bay	3
14. Streaky Bay	3

The more northerly populations (1-4, 12) (excluding 13 & 14) are more or less strongly differentiated from the other more southerly populations. The Kimba (1), Arno Bay (2) and Moonta (4) populations are collectively very homogeneous. The plants of these three localities have short leaves which are relatively broad, short pedicels and short calyces. In general, the density of hairs on the vegetative parts, pedicels and calyces is significantly greater than the density of glands for these same parts. With respect to the expression of these characters (character states), there is a parallel between these populations and the northern populations of *P. aspalathoides* (p. 252). Populations from Lock (3) and Hincks (12) are slightly differentiated from the former three populations (1, 2 & 4). The plants from these two localities frequently tend to have character states which are intermediate between the former three populations (1, 2 & 4) and the four coastal populations (9, 10, 13, & 14) (Figs 28 & 30). Overall, this is an area of phenetic heterogeneity, with some characters having character states similar to populations 1 and 2, whereas other characters having character states similar to some or all of the southern and western coastal populations (9, 10, 13 & 14).

There are strong coastal environmental factors operating on the mainland populations of 9-11, 13 & 14. A 'ridge' of strong differentiation separates populations 4 from 11, and 3 and 12 from 9, 10, 13 & 14 (Fig. 32). All of these populations (9, 10, 13 & 14) tend to be more glandular than the inland populations, except for the Venus Bay and Streaky Bay (13 & 14) populations which are very hairy. These coastal populations also have larger, shiny leaves which are often thickened, longer prophylls, longer pedicels (except populations 13 & 14), and larger calyces than the island specimens. These features are typical of many coastal species, e.g. *Ixodia achillaeoides* (Compositae) (Copley 1982), *Euphrasia collina* ssp. *tetragona* (Scrophulariaceae) (Barker 1982). Other examples and further details are given in Specht (1972; and literature cited therein). It is proposed that the phenotype of these coastal plants is significantly affected by environmental factors. The constitution of the genotype is not known, as my attempts to transplant specimens from these areas were unsuccessful. However, *P. calycina* has been cultivated (refer p. 240) and it maintained its distinctness.

Three major regions of differentiation occur between the five coastal populations under consideration. The two western populations (13 & 14) which represent *P. calycina* [for numerical analysis of this species refer pp. 239-242] are distinct from the other populations

(Fig. 32). The specimens from all the other populations belong to *P. serpyllifolia.* The Mt Greenly (10) population is characterized by specimens with long pedicels. This is further discussed under *P. serpyllifolia* (p. 295). The distinctness of population 9 (Fig. 32) is almost certainly largely an environmentally induced effect. Furthermore, when additional collections (not used in the production of the composite differential) are considered, this population is very heterogeneous and tends to intergrade with population 12. The Stenhouse Bay population (11) is made up of individuals which are glabrous or very sparsely hairy. These specimens have a very high glandular density on most organs. The taxonomic importance of the Mt Greenly form and the Stenhouse Bay form is not known. It seems unlikely that examination of normal macromorphological characters will resolve this part of the *P. serpyllifolia-P. microphylla* complex.

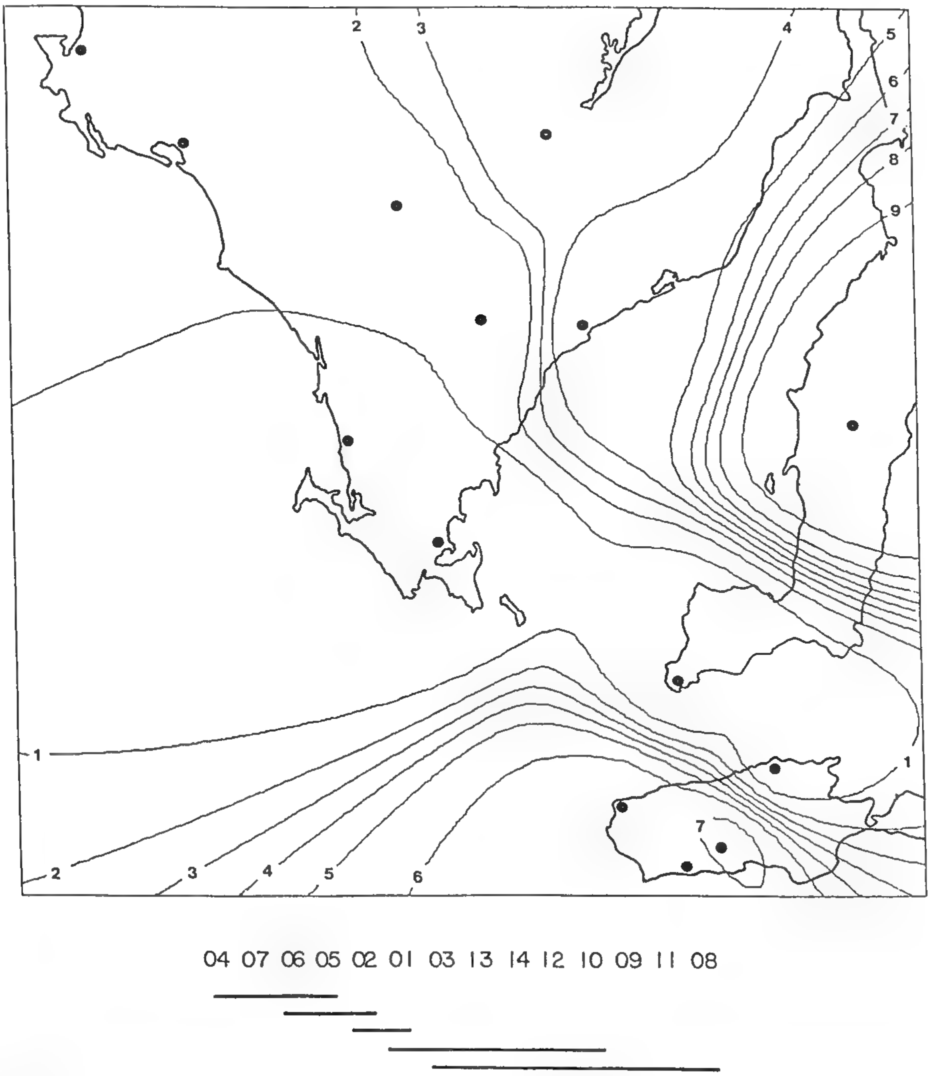


Fig. 28. Contour map (with summary of SNK test) of the density of hairs on the outer surface of the calyx (KHDO) for populations of the *P. calycina—P. microphylla—P. serpyllifolia* complex. Contour symbols and values are: 1 = 2.63; 2 = 7.68; 3 = 12.73; 4 = 17.78; 5 = 22.83; 6 = 27.88; 7 = 32.93; 8 = 37.98; 9 = 43.03.

The Investigator Strait and St Vincents Gulf represent significant barriers to interbreeding between the Kangaroo Island (5-8) and mainland populations (Fig. 23) (*cf. P. aspalathoides*, p. 254). The Kangaroo Island populations differentiate into two main groups. One group, which is represented by the Cape Borda (5), Kelly Hill Caves (6) and Mt Taylor (7) populations, is generally very hairy with many irregularly branched hairs. These three populations occur in sandy to sandy loam soils associated with limestone.

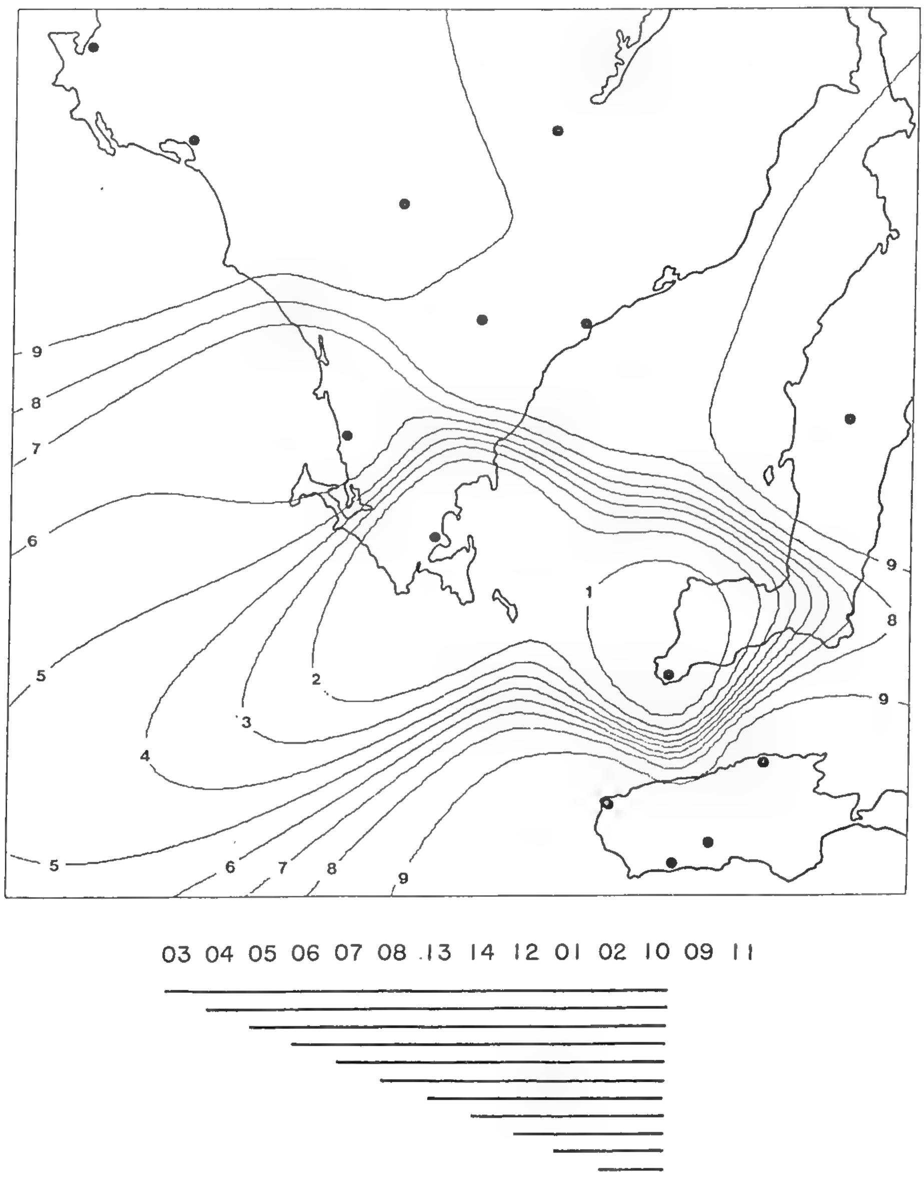


Fig. 29. Contour map (with summary of SNK test) of the position of hairs on the branches (INTER) for populations of the *P. calycina—P. microphylla—P. serpyllifolia* complex. Contour symbols and values are: 1 = 1.14; 2 = 1.24; 3 = 1.34; 4 = 1.44; 5 = 1.54; 6 = 1.64; 7 = 1.75; 8 = 1.85; 9 = 1.95.

The habitat of these populations is a *Eucalyptus* dominated mallee community with a more or less dense understorey of shrubs and herbs. The Cape Cassini (8) population, which represents the second group, is associated with skeletal soils of exposed coastal limestone cliffs. These plants are more or less prostrate and are salt-pruned. Most characters for the plants at Cape Cassini show slight (although generally insignificant) differences when compared with populations 5-7. However, in general, the plants are glabrous on most organs, or at least, usually less hairy (with the occasional exception of branches) than the plants of populations 5, 6 and 7. In contrast to these latter populations, the plants from Cape Cassini have only simple hairs, similar to those found throughout most of section *Klanderia*. The taxonomic significance of the irregularly branched hairs, as found in the plants of populations 5-7 (and *P. chlorantha*), is not known.

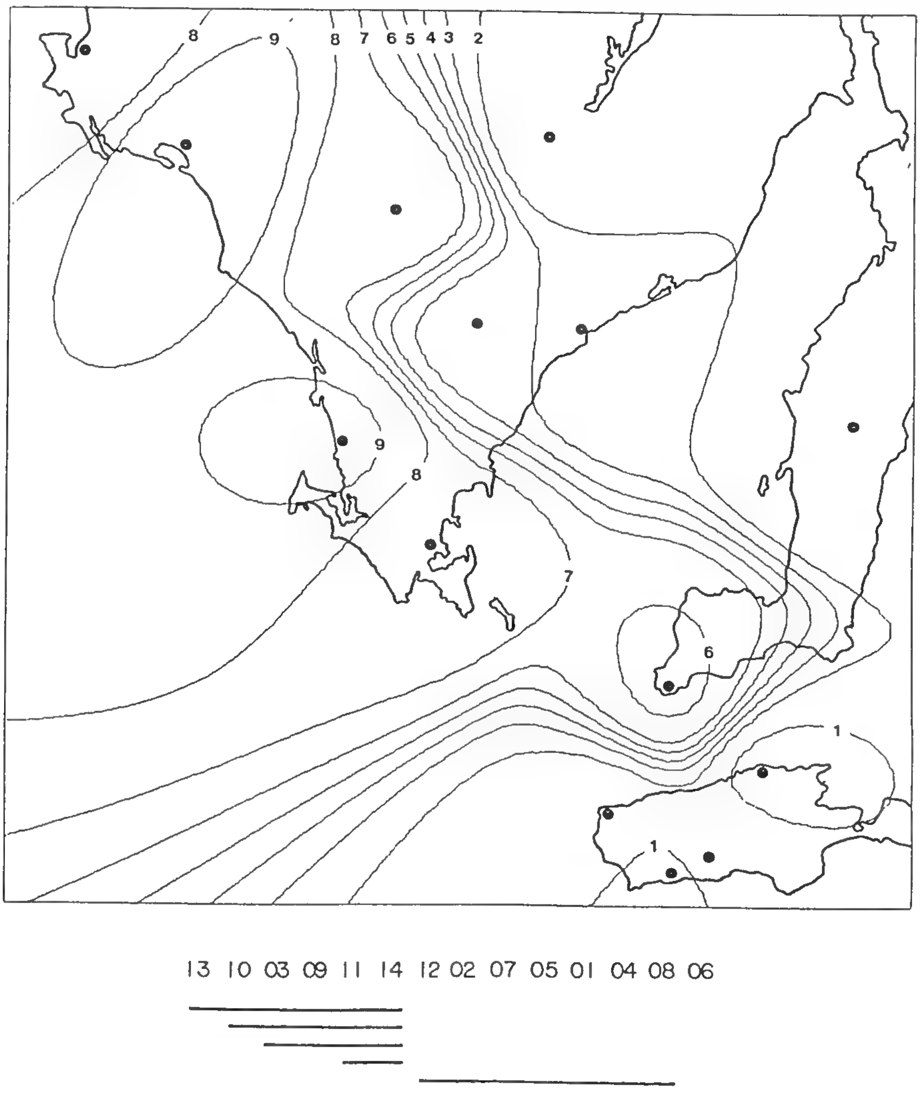
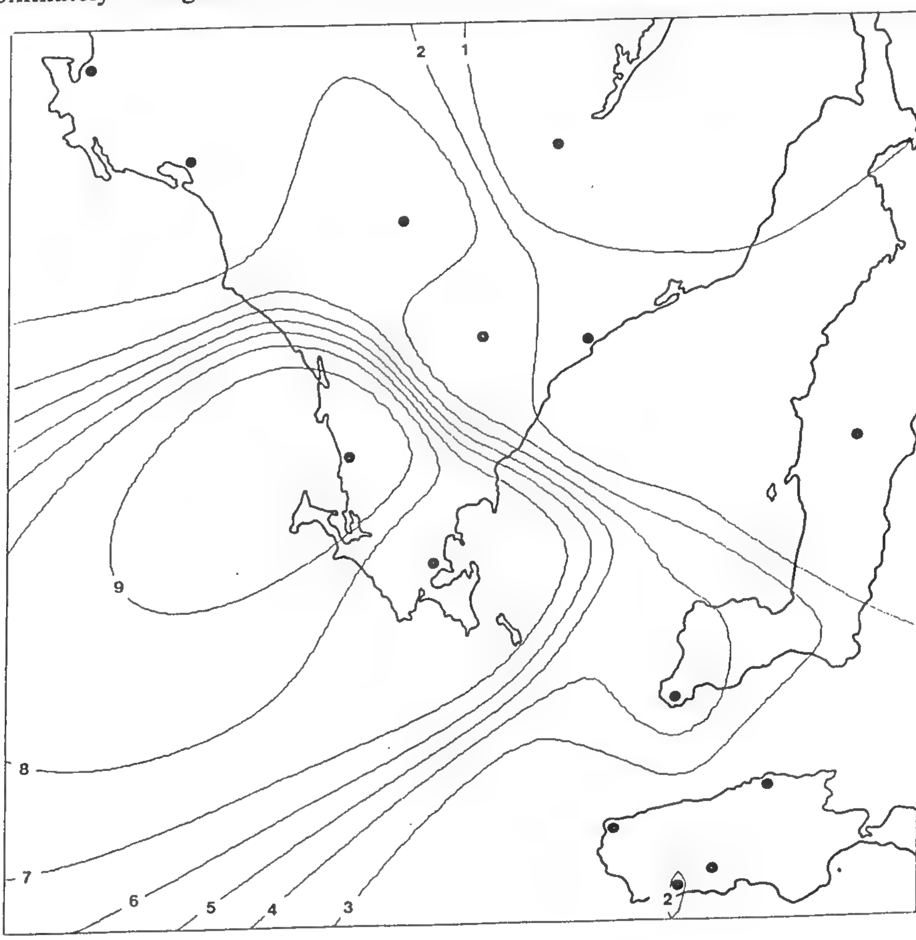


Fig. 30. Contour map (with summary of SNK test) of the lamina length (LL) for populations of the *P. calycina—P. microphylla—P. serpyllifolia* complex. Contour symbols and values are: 1 = 1.93; 2 = 2.39; 3 = 2.85; 4 = 3.31; 5 = 3.77; 6 = 4.23; 7 = 4.69; 8 = 5.14; 9 = 5.60.

P. calycina and *P. serpyllifolia* (incl. *P. microphylla*) occur in soils derived from, or at least associated with calcarenites, with the exception of the Mt Greenly population (and some specimens from Port Lincoln, p. 295, which were not included in the composite differential) which occurs in association with quartzites and granitic gneisses. The phenotype of the Mt Greenly and Kirton Point (Port Lincoln) populations of *P. serpyllifolia* may have been induced (at least in part) by the relatively unique geological nature of these areas. Whether there is a corresponding genetic distinctness is not known.

In New South Wales, Victoria, most of Western Australia, and the Murray Mallee region of South Australia, *P. serpyllifolia* is confined to the SemiArid Moisture region (Gentilli 1972), with phytohydroxeric indices between 5 and 10. In the area dealt with by this study of the pattern of geographic variation (Fig. 27), SubHumid (SH), SemiArid (SA) and Arid (A) Moisture regions occur, with phytohydroxeric indices ranging from approximately 3 to greater than 10. In figure 33, the average annual rainfall (adapted



10 09 11 03 13 14 05 12 08 07 06 04 02 01

Fig. 31. Contour map (with summary of SNK test) of the pedicel length (LP) for populations of the *P. calycina*—*P. microphylla*—*P. serpyllifolia* complex. Contour symbols and values are: 1 = 1.78; 2 = 2.75; 3 = 3.73; 4 = 4.70; 5 = 5.68; 6 = 6.66; 7 = 7.64; 8 = 8.62; 9 = 9.59.

from Laut *et al.* 1977b, 1977c), annual phytohydroxeric indices and moisture regions (Gentilli 1972), have been overlaid on the contour map (from differential systematics) for *P. calycina* and *P. serpyllifolia* (*cf.* Fig. 32).

In this region of South Australia, the coastline is deeply indented by elongated gulfs and peninsulas. This alternation of land and water surfaces results in a large number of localized climatic modifications. Although these modifications are too slight to be of regional significance, they represent very important climatic influences for the local biota. The SubHumid Moisture region (phytohydroxeric indices ≥ 10) discontinuously occurs on the western parts of Kangaroo Island, the most southerly point of Yorke Peninsula (Innes National Park), and the southern parts of Eyre Peninsula (Fig. 33). Populations 5-7, 9 and 11 occur in this region, whereas populations 4, 8 and 10 occur in the SemiArid Moisture region. As well as the Moonta (4) population being morphologically similar to those populations of Victoria and New South Wales, it also occurs in the same climatic zone. Although the Cape Cassini (8) population occurs in the SemiArid Moisture region, the actual level of aridity is probably greater because it occurs on the exposed coastal cliff. The environmental factors operating on population 8 are dramatically different to that operating on the other Kangaroo Island populations (5-7). These climatic differences may explain why the Kangaroo Island populations have differentiated into two main groups.

Fig. 32. The composite differential formed from 18 characters in populations of the *P. calycina—P. microphylla—P. serpyllifolia* complex. Contour symbols and values are: 1 = 0.04; 2 = 0.06; 3 = 0.09; 4 = 0.11; 5 = 0.14; 6 = 0.16.

Although Mt Greenly (10) occurs in the SemiArid Moisture region, the local topography associated with its relatively high latitude and proximity to the ocean (hence, increased exposure to the westerly streams of oceanic air), results in this population being under more SubHumid conditions than indicated by the generalized climatic map overlaid in figure 33.

The angle of the western coastline of Eyre Peninsula prevents the rain-bearing winds from penetrating deeply inland (Gentilli 1972). Populations 1-3 and 12 occur in the Arid Moisture region (phytohydroxeric indices between 3 and 5). Although the Arno Bay (2) population is more or less coastal, the major climatic influences are from the west. Therefore, the coastal influences only slightly modify the inland arid conditions. Populations 13 and 14 also occur in this moisture region because the rain-bearing winds tend to be tangential to the coastline (the isohyets tending to lie parallel to the west coast, Laut *et al.* 1977c, Fig. 1). Since Venus Bay and Streaky Bay occur at lower latitudes, they are not as strongly influenced by the westerly oceanic air currents as are the more southerly land points. The moisture region in association with the high salt content of the air (in this coastal environment), exposes *P. calycina* to a different set of environmental factors when compared with the other coastal populations of Eyre Peninsula.

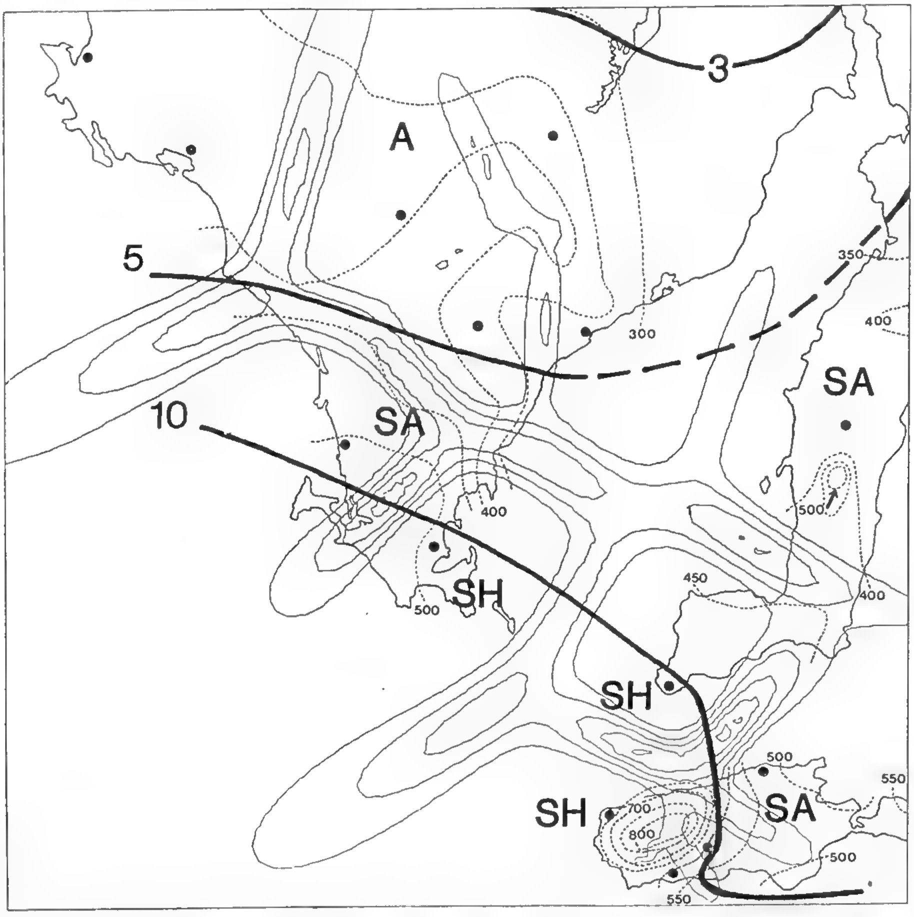


Fig. 33. Annual rainfall distribution (mm) (fine dotted lines), Moisture regions (bold capital letters) and phytohydroxeric indices (bold numbers and lines) overlaid onto the composite differential formed from 18 characters in the populations of the *P. calycina—P. microphylla—P. serpyllifolia* complex. For contour symbols and values refer Fig. 32. For explanation of symbols used for moisture regions refer text, pp. 260, 261.

Morphological variation in the *Prostanthera laricoides* complex

The Western Australian specimens included in this numerical study of section *Klanderia* (excluding *P. serpyllifolia* ssp. *microphylla*), which are regarded as distinct from the taxa of South Australia and the eastern States (Figs 6 & 8), were studied in more detail. Previously they were regarded as *P. aspalathoides* (populations 1-7 or *P. microphylla* (8) (Fig. 34). The details of the eight populations (based solely on herbarium collections), including the number of specimens in each population, are given in Table 11 and figure 34. For the taxonomic conclusions from the numerical analyses refer pages 243-245.

Of the original 23 characters, 22 showed both a significant *F*-test and a significant SNK test (both at the 0.01 level). Characters STBB, STHL, STHW and STMX (refer Table 1) were deleted from the character set because some individuals had glabrous branches. The remaining 19 characters were used in the analysis of the pattern of geographic variation for these taxa.

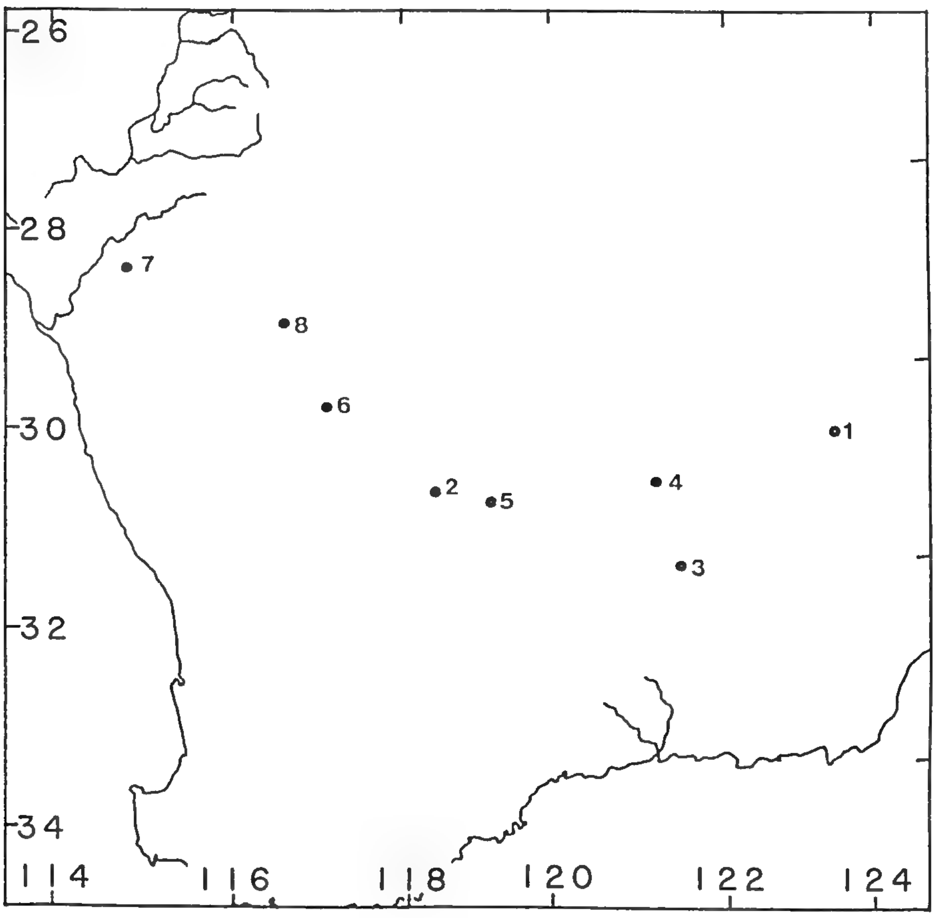


Fig. 34. Locality details of the 8 populations of the *P. laricoides* complex used for morphological variation studies. 1 = Cundeelee; 2 = Campion; 3 = Lake Cowan; 4 = Kalgoorlie; 5 = Southern Cross; 6 = Mt Churchman; 7 = Pindar; 8 = Paynes Find. For further details of populations refer Table 11.

Table 11. Details of the 8 populations of the *P. laricoides* complex used for morphological variation studies.

Approximate locality of Population	Number of specimens/Population
WESTERN AUSTRALIA	
1. Cundeelee	5
2. Campion	6
3. Lake Cowan	5
4. Kalgoorlie	6
5. Southern Cross	5
6. Mt Churchman	5
7. Pindar	7
8. Paynes Find	5

Considering each character separately, there are four main pattern types. One common type of pattern of geographic variation is illustrated by the length of the anther appendage —AAL (Fig. 35). Populations 1 (*P. laricoides*) and 8 (*P. patens*) have specimens which have long appendages on the anthers, whereas the other populations have short appendages or the appendages are absent. Slightly more structure to the pattern of variation is found in the contour map of the position of the hairs on the branches—INTER (Fig. 36). *P. patens* (8) has hairs on all 'sides' of the axes, whereas *P. laricoides* (1) and *P. incurvata* (3 & 4) have hairs on two 'sides'. Populations 5 & 6 (*P. semiteres p.p.*) and *P. pedicellata* (7) have glabrous or very sparsely hairy axes. The density of hairs on the branches (STHD), the position of the prophylls (LKLP), and the density of hairs on the outer surface of the calyx (KHDO) all show patterns of variation comparable to this common type. In general, populations 1 (*P. laricoides*) and 8 (*P. patens*) have significantly high values for the respective character, whereas the other populations (2-7) have significantly low values.

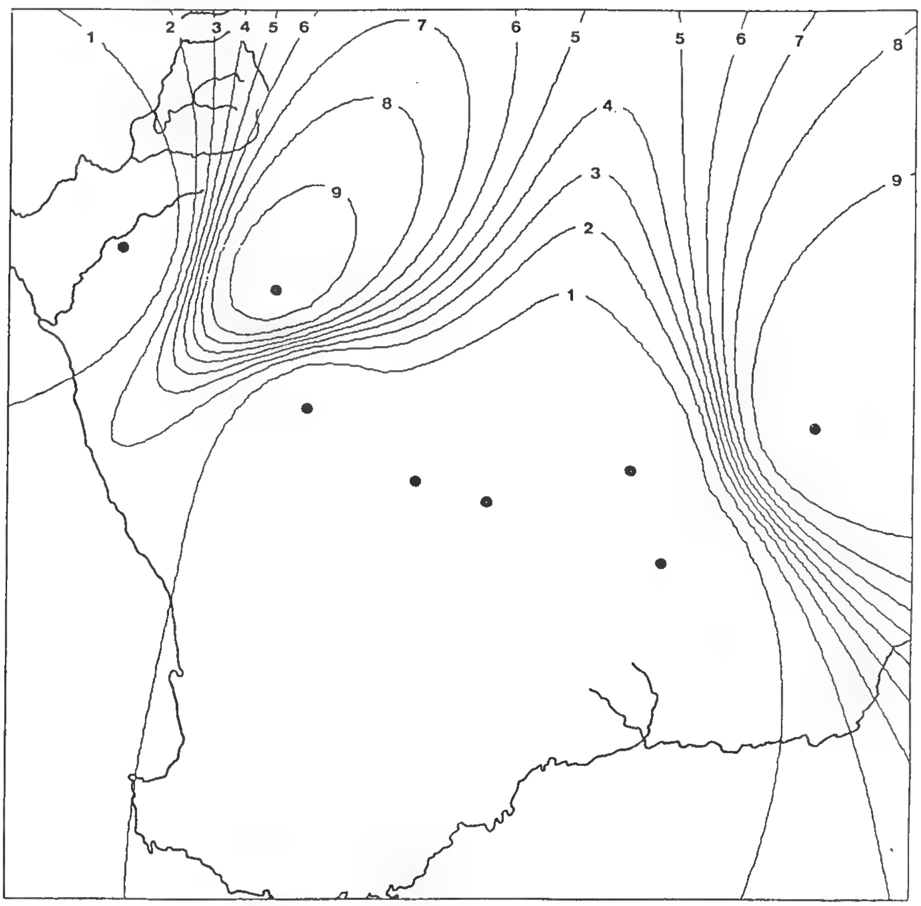
Table 12. Details of the 44 collections used in the study of morphological variation in the *P. laricoides* complex.

1. Royce 5472	23. Wilson 3508
2. Royce 5371	24. Wilson 3515
3. Boswell F66	25. Chinnock 3132
4. Butler *s.n.*	26. Ashby 3585
5. Main *s.n.*	27. Blackall 3452
6. Beard 4744	28. Rosier 309
7. Canning CBG 26146	29. Rosier 251
8. Phillips CBG 23274	30. Weber 5188
9. Newbey 2538	31. Beard 5944
10. George 2670	32. Demarz 5261
11. Gardner 2060	33. Ashby 2993
12. Blackall 979	34. Ashby 3931
13. Burbidge 2664	35. Ashby 5112
14. Blackall 896	36. Ashby 5035
15. Gardner 2797	37. Maiden *s.n.*
16. Broadbent 1054	38. Phillips CBS 54467
17. Bale 123	39. Beard 6687
18. Kemsley *s.n.*	40. Burns 1037/2
19. Phillips CBG 23260	41. Alpin 2551
20. Lidgey 5 & 7	42. Steenbohm *s.n.*
21. Wilson 3112	43. Ashby 5209
22. Chinnock 3055	44. Ashby 5220

Another common type of pattern of geographic variation is illustrated by the length of the lamina—LL (Fig. 37). *P. laricoides* (1) has long leaves which are significantly different from all other populations. Populations 7 (*P. pedicellata*), 6 (*P. semiteres* ssp. *intricata*)

and 8 (*P. patens*) have very short leaves. The other populations (2-5) have leaves of intermediate length between the two former groups. Other characters which have a similar pattern of variation include, the density of glands on the branches (STGD), the length to width ratio of the lamina (LLW), the density of glands on the outer surface of the calyx (KGDO), and the density of the glands on the lamina (LGD). In general, there is an east-west trend, such that population 1 (*P. laricoides*) has the largest values for the respective character, with populations 3 and 4 (*P. incurvata*), 5, 2 and 6 (*P. semiteres*), 8 (*P. patens*), and 7 (*P. pedicellata*) having progressively lower values.

The third common type is exemplified by the length of the pedicel—LP (Fig. 38). In this type of pattern of variation, there is a general west-east trend. The highest values for the respective character occur in population 7 or 8, with the more easterly populations tending to have progressively lower values. Other characters with a similar pattern of variation are the length of the petiole to the length of the lamina (LPLL), calyx length (KL), and calyx lobe to tube ratio (KLLT).



01 08 02 04 05 06 07 03

Fig. 35. Contour map (with summary of SNK test) of the anther appendage length (AAL) for populations of the *P. laricoides* complex. Contour symbols and values are: 1 = 0.08; 2 = 0.24; 3 = 0.39; 4 = 0.55; 5 = 0.71; 6 = 0.87; 7 = 1.02; 8 = 1.18; 9 = 1.34.

The final main type of geographic variation occurs for the length of the prophylls—BL (Fig. 39) and the length to width ratio of the prophyll (BLW). This type of pattern of variation is more or less opposite to the first type (refer Fig. 35). Populations 8 (*P. patens*) and 1 (*P. laricoides*) have short prophylls (Fig. 39) and small prophyll length to width ratios, whereas the other populations have long prophylls (Fig. 39) and large prophyll length to width ratios.

The composite differential formed from the 19 characters which showed both a significant *F*-test and a significant SNK test (both at the 0.01 level) is presented in figure 40. The most rapid areas of change occur between (i) *P. laricoides* (1) and *P. incurvata* (3 & 4), (ii) *P. incurvata* and *P. semiteres* (2, 5 & 6), (iii) *P. patens* (8) and all other populations, (iv) *P. pedicellata* (7) and all other populations.

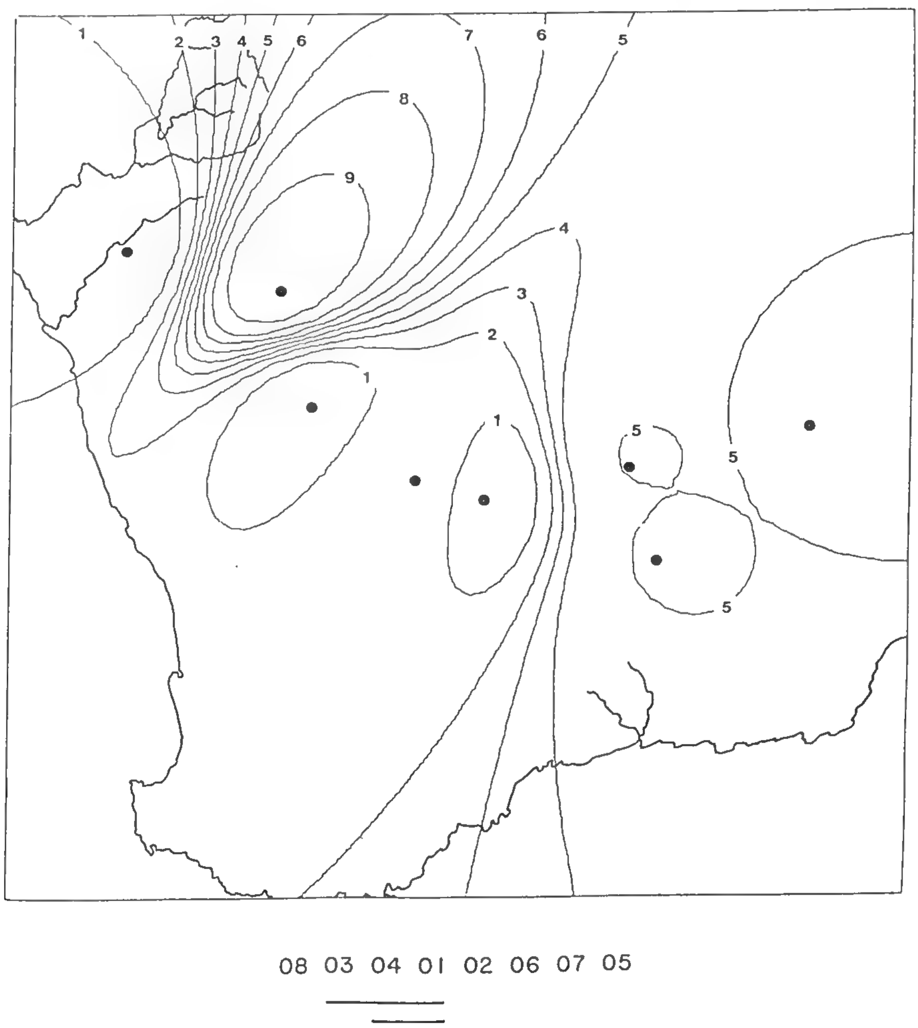


Fig. 36. Contour map (with summary of SNK test) of the position of the hairs on the branches (INTER) for populations of the *P. laricoides* complex. Contour symbols and values are: 1 = 0.11; 2 = 0.33; 3 = 0.55; 4 = 0.77; 5 = 0.99; 6 = 1.21; 7 = 1.43; 8 = 1.65; 9 = 1.87.

The interpretation of the various surface trend analyses and the composite differential is severely limited by the small number of individuals (44) included in this study and by the lack of field information. For example, it is not known if the populations represent interbreeding units. Most populations, as defined by this study, are very heterogeneous (Fig. 17) and additional collections may weaken the distinctness of some populations.

The prostantheras of this region are under-collected, but the present collection localities of the populations may more or less represent their actual distribution. If this is so, the disjunctions assumed here may exist. Based on field-label information (which is very inadequate), Sheets 5 and 10—SW Sheet (Atlas of Australian Soils, Division of Natl Mapping, Dept Natl Development, Canberra, 1968) and Stace *et al.* (1968), all taxa appear to be confined to light soils which are usually sandy to sandy-loam. *P. laricoides* occurs in

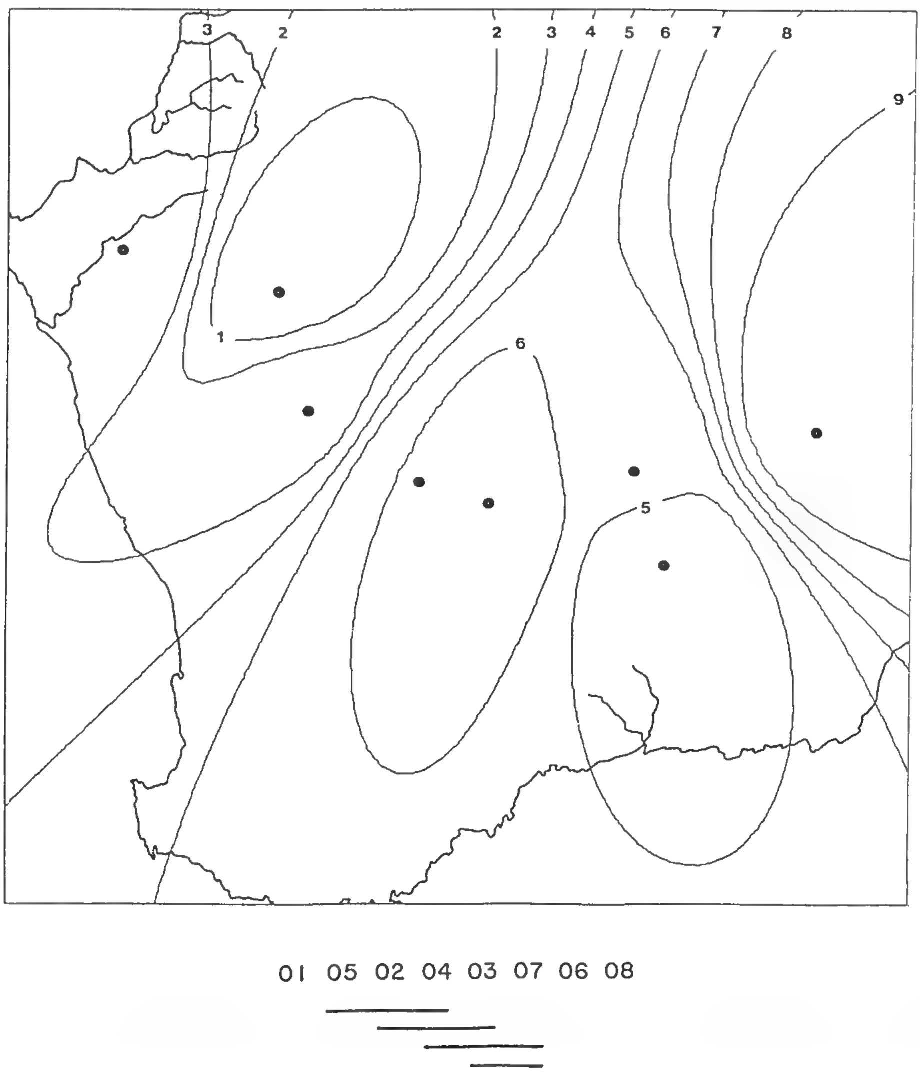


Fig. 37. Contour map (with summary of SNK test) of the lamina length (LL) for populations of the *P. laricoides* complex. Contour symbols and values are: 1 = 2.39; 2 = 3.71; 3 = 5.03; 4 = 6.35; 5 = 7.66; 6 = 8.98; 7 = 10.30; 8 = 11.62; 9 = 12.94.

red sands; *P. incurvata* occurs in shallow calcareous loamy soils (near Kalgoorlie) and in brown calcareous earths (near Lake Cowan); *P. semiteres* ssp. *semiteres* occurs in yellow earths; *P. patens* occurs in shallow earthy loams; and *P. pedicellata* occurs in yellow-brown earths with ironstone gravel on surface. The distribution of soils may represent an important factor controlling the distribution of these taxa. It is of interest to note that *P. pedicellata* and *P. semiteres* spp. *intricata*, which both have long pedicels, occur in yellow to yellow-brown earths.

Without further field information, climatic data does not appear to suggest useful hypotheses to explain the composite differential (Fig. 40). These taxa occur in the Arid Moisture region (Gentilli 1972) (populations 2, 3, 5-8 with phytohydroxeric indices between 3 and 5, populations 1 and 4 with phytohydroxeric indices between 2 and 3). Although it is tempting to suggest that *P. laricoides* (1) may, at least in part, be distinct because it occurs in a subdesert (Gentilli 1972) interzone between PerArid and Arid Moisture regions, it is noted that it has been collected from amongst rocks. This taxon may be sufficiently sheltered to avoid the harshness of the subdesert interzone, such that the microclimate may be similar to that of the other populations (2-6).

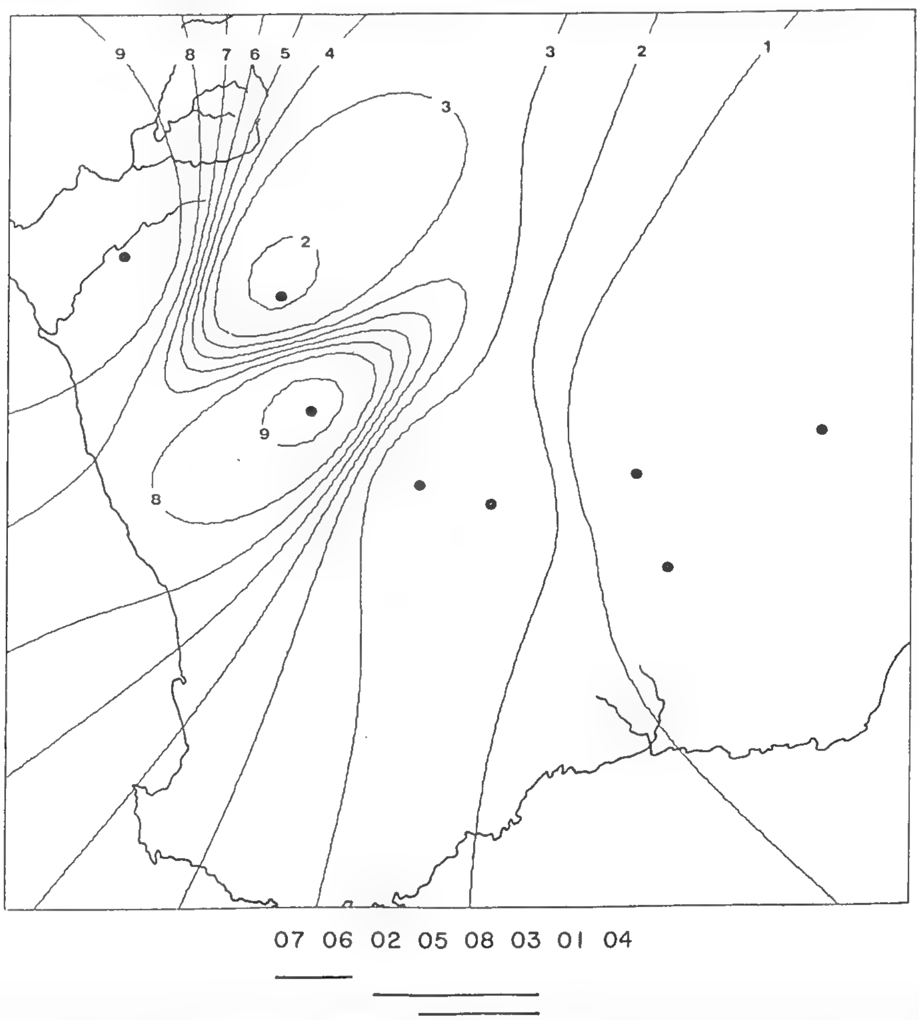


Fig. 38. Contour map (with summary of SNK test) of the pedicel length (PL) for populations of the *P. laricoides* complex. Contour symbols and values are: 1 = 2.79; 2 = 3.31; 3 = 3.83; 4 = 4.35; 5 = 4.87; 6 = 5.39; 7 = 5.91; 8 = 6.43; 9 = 6.95.

Conclusions from geographic variation studies

In the three previously discussed studies I have used geographic variation analysis in two ways. In the study of the *P. aspalathoides* complex I used the various techniques to study the variation within a single species, whereas in the latter two complexes (*P. calycina-P. microphylla-P. serpyllifolia, P. laricoides*) more than one species was involved in each. With respect to my work, the first two aims of geographic variation studies as summarized by Gould & Johnston (1972) have been accomplished. The actual pattern of morphological variation has been established in all three complexes. This has made it possible to suggest and test (subjectively) possible causes for these patterns. Climatic and environmental conditions have been proposed as causal factors influencing the observed morphological variation in *P. aspalathoides, P. calycina* and *P. serpyllifolia*. However, there appears to be relatively little climatic and/or environmental differentiation which could explain the morphological variation observed in the *P. laricoides* complex. Detailed field information on this latter complex is required.

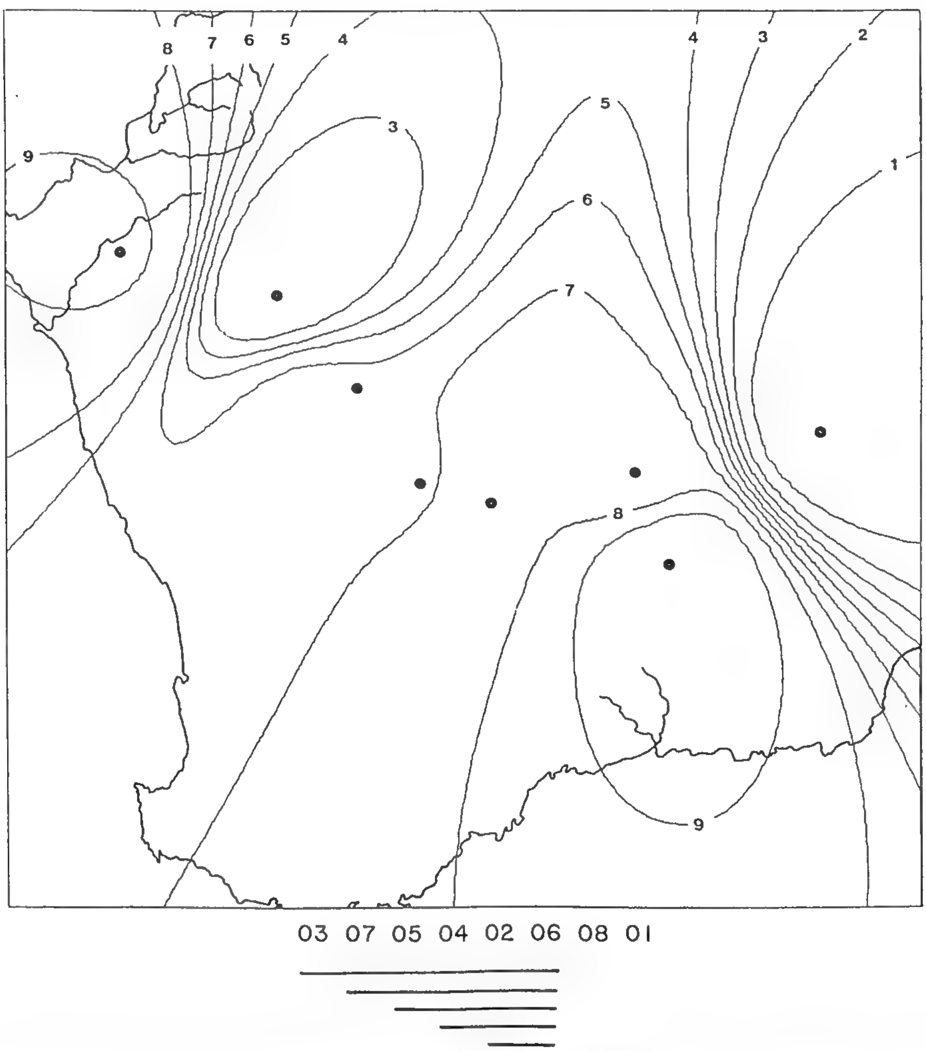


Fig. 39. Contour map (with summary of SNK test) of the prophyll length (BL) for populations of the *P. laricoides* complex. Contour symbols and values are: 1 = 5.11; 2 = 5.36; 3 = 5.62; 4 = 5.88; 5 = 6.13; 6 = 6.39; 7 = 6.64; 8 = 6.90; 9 = 7.16.

Gould and Johnston's (1972) third aim (*viz.* 'to determine if any trends of evolution or speciation are implied by such patterns of variation') is more difficult to accomplish. For instance, one of the main problems is the determination of the evolutionary significance of the morphological differences observed between taxa. This is particularly relevant in this study where character differences are quantitative and so may be of reduced evolutionary significance.

Since the Kangaroo Island populations of both *P. aspalathoides* and *P. serpyllifolia* are relatively distinct from their respective mainland populations, this suggests that these populations may be genetically drifting away from the mainland populations. However, it is not possible to hypothesize on the possible mode of speciation or to provide further insights into the lines of migration of these species because insufficient information was provided by the geographic variation analyses. With respect to the *P. laricoides* complex, no obvious trends of speciation or lines of migration were detected.

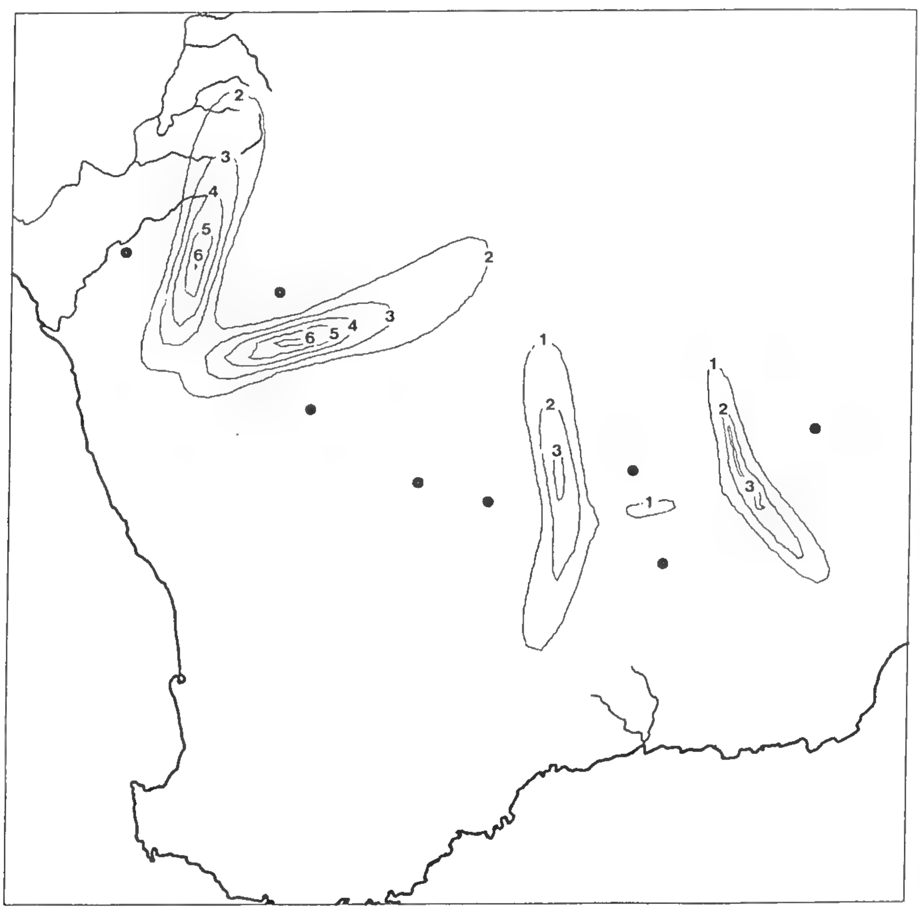


Fig. 40. The composite differential formed from 19 characters in populations of the *P. laricoides* complex. Contour symbols and values are: 1 = 0.04; 2 = 0.10; 3 = 0.16; 4 = 0.22; 5 = 0.27; 6 = 0.33.

Volatile oils (terpenoids)

Volatile oils are valid taxonomic characters (von Rudloff 1975) which have proved useful in the study of specific and infraspecific variation (e.g. Adams 1970b, 1972a; Adams & Turner 1970; Emboden & Lewis 1967; Flake *et al.*, in Runeckles & Mabry 1973; Hefendehl & Murray 1972; Turner 1970; von Rudloff 1967, 1972a, 1973, 1975; Whiffin 1978; Zavarin & Snajberk 1973), and in the detection of hybrids (e.g. Whiffin 1977, 1981; Zavarin *et al.* 1969). They have also proved to be a convenient, accurate and a significant source of data which can be used to characterize individuals or populations. Although there is some subjectivity in the choice of the method of extraction and analysis, the final data are essentially, objectively derived.

The detail of the biosynthesis of volatile oils is relatively unknown, although significant advances have been made by a number of workers (refer Loomis & Croteau, in Runeckles & Mabry 1973). Similarly the mechanism of genetic control of the metabolic processes have not been fully clarified, but in general, the inheritance of most compounds appears to be under the control of one or a few genes (e.g. Irving & Adams, in Runeckles & Mabry 1973).

Materials and methods

Hanover (1966a) and von Rudloff (1972a) have shown that environmental factors have little or no effect on the composition of the volatile oils, but the amount of oil produced may be influenced by such factors. The amount and composition of the oil produced is affected by the maturity of the leaves (Adams & Hagerman 1976; Firmage & Irving 1979; Hanover 1966a; Maarse & Kepner 1970; von Rudloff 1972b; Zavarin *et al.* 1971), and may also be affected by seasonal variation (e.g. Adams 1970a; Attaway *et al.* 1967; Maarse & Kepner 1970; Powell & Adams 1973; von Rudloff 1967, 1972b; Zavarin *et al.* 1971). To minimise such affects, all samples were collected during mid- to late 'spring' (September-early November). Spring is here defined as the season when mature flowers are common throughout the population being sampled. Therefore, collections from Kangaroo Island in November, are regarded as comparable to collections from lower latitudes in September. Adams (1970a), Cheng & von Rudloff (1970), and other workers, recommend that chemosystematic studies should be carried out during autumn and winter because this is the period in which the oil composition is most stable. For various reasons, this was not possible and so great care was taken to ensure that only the previous seasons mature (c. 1 year old) leaves were sampled. To minimize diurnal effects (Adams & Hagerman 1977, Adams 1979) most collections were made between 10 a.m. and 1 p.m.

Fresh foliage samples from each plant were sealed in polyethylene bags, kept as cool as possible until air-freighted to Adelaide, where they were stored at approximately 2° C until processed. Since the samples were kept at low temperatures none were apparently affected by 'sweating' (Penfold & Willis 1961).

Fresh foliage (10-30 g) was steam distilled in an all-glass apparatus (modification of Forss & Holloway 1967). The oil was extracted and concentrated according to Whiffin (1978), except that the oil was extracted into ether instead of freon 11. Oil samples were concentrated with a jet of high-purity nitrogen and stored under that gas in sealed vials at -20° C until analysed.

The oils were analysed on a Perkin Elmer 900 gas-liquid chromatograph, using 15 m x 0.5 mm i.d. FFAP coated stainless steel SCOT columns with He (at 2.5 psi) as carrier gas. Individual runs (with injection size 0.3 μl) were held at 80° C for 3 min., then temperature programmed from 80 to 170° C at 6°/min., and finally held at 170° C for 30 min. Gas flow rates for the flame-ionization detector were: Air 30 psi; H_2 22 psi. Individual components were identified by their retention times and by co-injection with authentic compounds. A Hewlett Packard 3370A Integrator was used to determine percentage compositions.

Table 13. Mean % composition of selected volatile leaf oils of *P. aspalathoides*.

	Populations					
	1	2	3	4	5	6
COMPOUND						
1. α - Pinene	tr	0.4	4.3	0.8	2.4	1.4
2. β - Pinene	0.8	2.9	9.98	0.9	4.7	4.2
3. $C_{10}H_{16}$	0.4	0.7	0.48	0.8	2.6	0.4
4. $C_{10}H_{16}$	0	0.7	0.3	0	0	0
5. Limonene	0.7	0.78	3.1	0.4	1.3	0.5
6. 1,8-Cineole	33.5	41.3	45.2	41.1	41.0	29.4
7. ρ - Cymene	2.9	0.9	0.4	1.0	1.1	0.6
8. $C_{10}H_{14}O$	1.0	1.2	0.3	0.1	0.1	0.4
9. $C_{10}H_{18}$	1.4	0.6	0.8	0.1	0.1	0.6
10. Terpinen-4-ol	0.7	0.9	0.5	1.0	1.1	1.2
11. $C_{10}H_{14}O$	0.9	2.1	1.2	0.4	0.1	1.1
12. $C_{10}H_{16}O$	0.9	2.7	0	0.2	0.6	0.3
13. $C_{15}H_{24}$	6.8	4.7	2.7	4.4	3.1	1.4
14. $C_{15}H_{24}$	0.3	0.6	0	0.2	0.1	0.2
15. $C_{10}H_{16}O$	0.7	1.8	0.3	1.0	0.1	0.6
16. α - Terpineol	1.2	3.7	0.7	2.9	0.6	0.4
17. $C_{10}H_{18}O$	3.7	0.4	0.6	1.1	0.1	0.4
18. $C_{15}H_{24}$	1.0	0.7	1.3	0.5	0.5	0.5
19. $C_{10}H_{16}O$	0.4	1.9	1.2	0.6	0.6	3.3
20. $C_{10}H_{14}O$	tr	0.3	0.4	0.4	0.1	0.2
21. Maaliol	34.0	0.2	tr	8.7	1.8	0.3
22. $C_{15}H_{26}O$	3.5	3.5	0.5	4.2	4.6	8.8
23. Globulol	2.1	5.2	4.5	2.2	3.6	6.7
24. Viridiflorol	0.4	0.8	1.0	5.6	11.1	2.2
25. $C_{15}H_{22}O$	0.3	0.1	tr	0.2	0.1	0.3
26. $C_{15}H_{24}O$	0.4	0.4	1.3	1.1	0.1	0.5
27. $C_{15}H_{26}O$	0.3	16.5	tr	0.3	0	0.01

Each individual component of the volatile oils was assigned a unique number by superimposition of the chromatograms and by comparison of retention times. Adams (1972b) regards the errors resulting from miscomparison as only slightly affecting comparisons between taxa. The retention times of α - Terpineol and Limonene, checked after each run, were used as standards. Thirty-seven consistently separable components were obtained. Since it is often difficult to determine whether a compound is present in trace amounts or absent (Southwell 1973), all variation in the data is regarded as quantitative rather than qualitative. Those components which were present in amounts less than 0.1% of the total oil were called 'traces' (refer Table 13) and were given an arbitrary value of 0.1%. Since the biogenesis of unknown compounds can not be known, there is a very real danger that some characters ('peaks') may represent one biogenetical system (Weimarck 1972), whereas others may represent several independent systems. Even though some characters may be highly correlated because they belong to the one biogenetical parthway, they receive equal 'weighting' with other characters in the various numerical analyses. Although I was unable to avoid the effects of the above type of character correlation, because the biogenetic pathways are not known for *Prostanthera*, only those chemical characters whose identity had been verified, at least tentatively (using the previously discussed techniques), were used in subsequent analyses (Table 13). My final volatile leaf-oil character set is based on that used by Lassak (1980).

Numerical analyses of volatile leaf-oils of *Prostanthera aspalathoides*

The volatile leaf oils of forty-four individuals of *P. aspalathoides* were sampled (refer figure 44 for details of specimens). The location of these populations is shown in figure 41, with further details in Table 14.

Table 14. Details of the 44 collections used in the study of the volatile leaf oil variation of *P. aspalathoides*.

Population	Number of specimens/population
SOUTH AUSTRALIA	
1. American River	3
2. Kingscote	22
3. Braendler's Scrub	3
VICTORIA	
4. Little Desert	4
5. Bendigo	5
NEW SOUTH WALES	
6. Rankin Springs	7

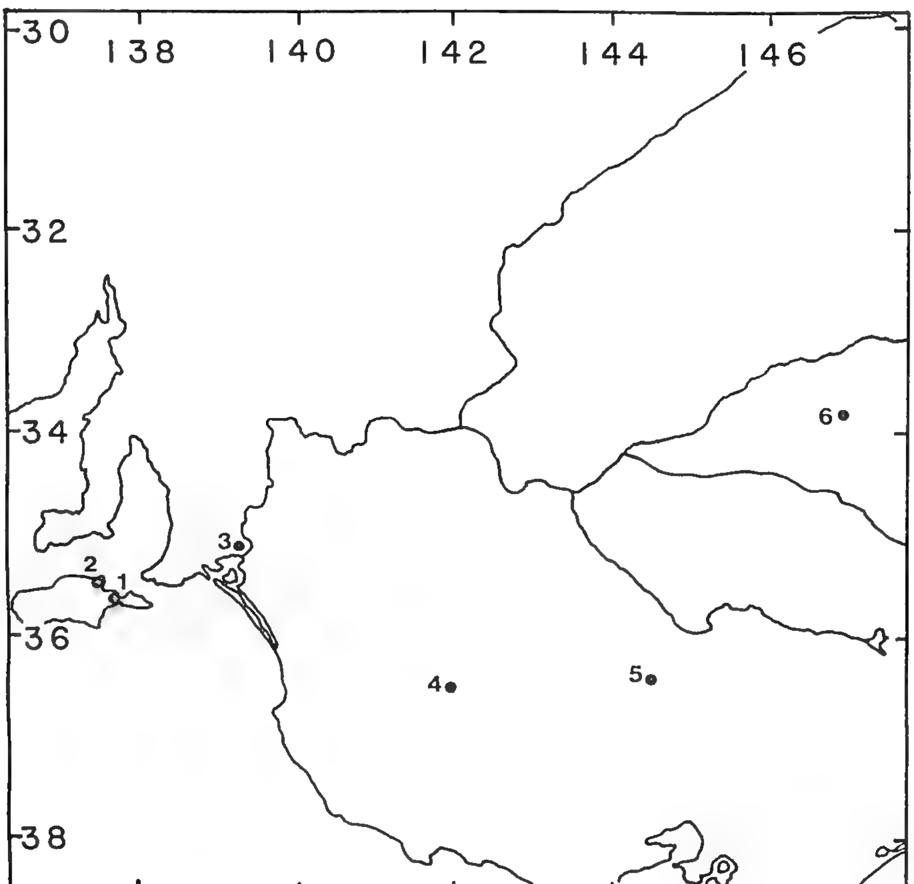


Fig. 41. Locality details of the 6 populations of *P. aspalathoides* used for volatile leaf oil variation studies. 1 = American River; 2 = Kingscote; 3 = Braendler's Scrub; 4 = Little Desert; 5 = Bendigo; 6 = Rankin Springs. For further details of populations refer Table 14.

Evaluation of volatile leaf-oil character set

Most characters (70.4%) were nonparametrically distributed. Kurtosis and skewness values are presented in Table 15. All characters appear to provide a high level of 'uniqueness' with respect to their information content (-0.60 < Kendall's tau < + 0.60, Table 16). The first three axes (factors) of principal factor analysis account for 48% of the variance. Those characters with high scores on these three factors are summarized in Table 17. Characters 8, 11-16 and 27 tend to cluster in the plot of factor 1 versus factor 2 (Fig. 42), scoring high on factor 1 (Table 17), but low on all other factors. Characters 1, 2, 4, 5 and 7 loosely cluster in the plot of factor 2 versus 3 (Fig. 43), scoring high on factor 2 (Table 17). It can also be seen that characters 9, 13, 17 and 21 have high positive scores (Fig. 43, Table 17).

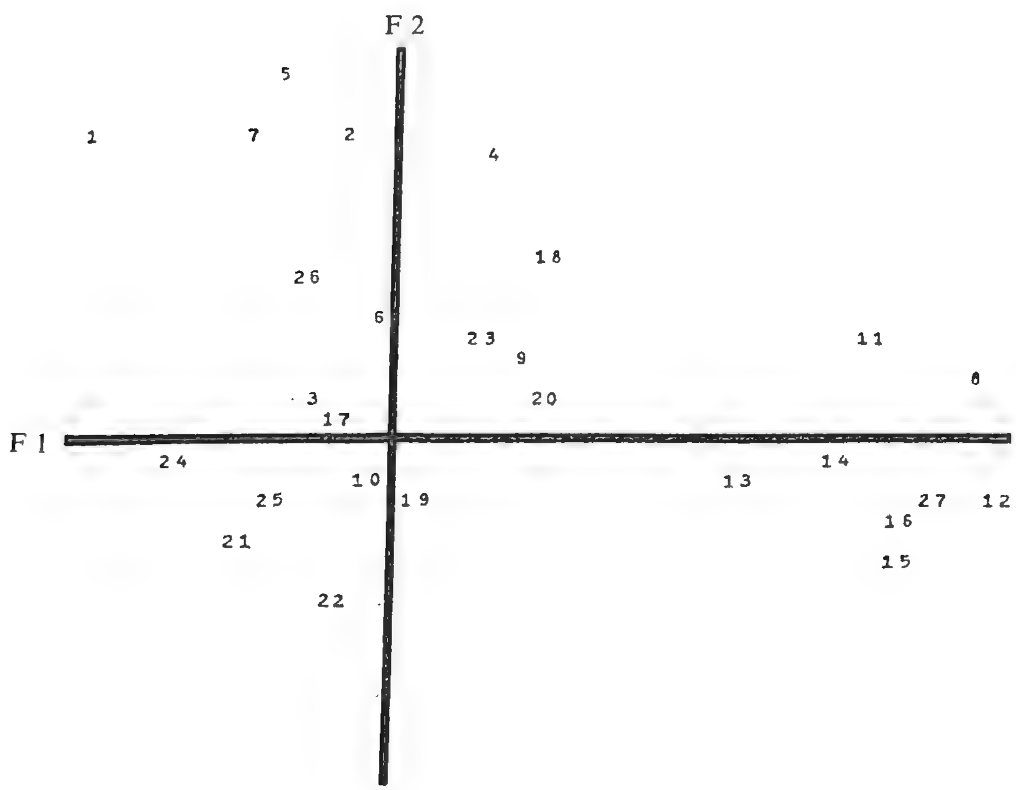


Fig. 42. Principal factor plot (function 1 versus function 2) of the volatile leaf oils of *P. aspalathoides*. For further details of volatile leaf oils refer Table 15.

Table 15. Kurtosis and skewness values for 27 volatile leaf oil compounds of *P. aspalathoides*.

Character	Kurtosis	Skewness
1. α-Pinene	5.45	2.23
2. β-Pinene	9.63	2.67
3. $C_{10}H_{16}$	1.34	1.12
4. $C_{10}H_{16}$	3.74	1.12
5. Limonene	6.64	2.17
6. 1,8-Cineole	-0.85	-0.56
7. ρ-Cymene	2.07	1.32
8. $C_{10}H_{14}O$	-1.23	-0.10
9. $C_{10}H_{18}$	0.21	0.74
10. Terpinen-4-ol	18.44	3.74
11. $C_{10}H_{14}O$	-0.36	0.14
12. $C_{10}H_{16}O$	-1.33	0.13
13. $C_{15}H_{24}$	-0.05	-0.14
14. $C_{15}H_{24}$	1.54	1.07
15. $C_{10}H_{16}O$	-1.30	-0.04
16. α-Terpineol	-0.45	0.69
17. $C_{10}H_{18}O$	11.04	3.26
18. $C_{15}H_{24}$	5.35	1.81
19. $C_{10}H_{16}O$	33.91	5.58
20. $C_{10}H_{14}O$	-0.18	0.93
21. Maaliol	9.80	3.17
22. $C_{15}H_{26}O$	26.21	4.69
23. Globulol	3.83	1.54
24. Viridiflorol	4.57	2.42
25. $C_{15}H_{22}O$	8.13	2.79
26. $C_{15}H_{24}O$	2.61	1.58
27. $C_{15}H_{26}O$	-1.24	0.67

Table 16. Correlation coefficients for selected character-pairs (Kendall's tau) for volatile leaf oils of *P. aspalathoides*.

Character-pair	Kendall's tau
C1 — C2	0.4907
C2 — C5	0.5751
C2 — C7	0.5061
C4 — C20	0.4910
C8 — C11	0.5064
C8 — C12	0.5623
C8 — C14	0.6018
C8 — C16	0.5204
C8 — C19	0.5198
C11 — C19	0.5117
C12 — C15	0.5761
C12 — C16	0.5954
C12 — C27	0.5922
C15 — C16	0.5484
C16 — C27	0.5586

Table 17. Volatile leaf oil compounds with high factor scores on the first three extracted factors from Principal factor analysis.

Factor 1		Factor 2		Factor 3	
12. $C_{10}H_{16}O$	0.887	18. $C_{14}H_{24}$	0.798	21. Maaliol	0.742
15. $C_{10}H_{16}O$	0.828	2. β-Pinene	0.725	17. $C_{10}H_{18}O$	0.651
27. $C_{15}H_{26}O$	0.768	5. Limonene	0.643	6. 1,8-Cineole	-0.613
8. $C_{10}H_{14}O$	0.744	4. $C_{10}H_{16}$	0.610	9. $C_{10}H_{18}O$	0.575
1. α-Pinene	-0.738	23. Globulol	0.519		
16. α-Terpineol	0.729	26. $C_{15}H_{24}O$	0.511		
11. $C_{10}H_{14}O$	0.629				
14. $C_{15}H_{24}$	0.624				
13. $C_{15}H_{24}$	0.534				
5. Limonene	-0.518				

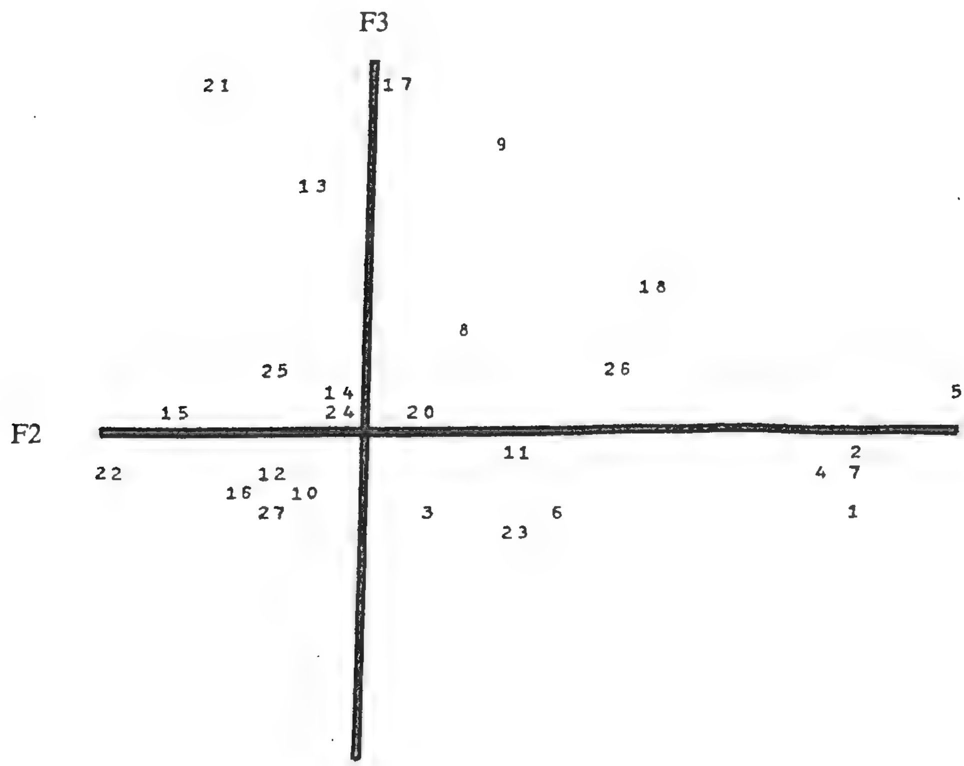


Fig. 43. Principal factor plot (function 2 versus function 3) of the volatile leaf oils of *P. aspalathoides*. For further details of the volatile leaf oils refer Table 15.

Numerical analyses of specimens

Whiffin (1982b) suggests that volatile oil data sequentially standardized by standard deviation is marginally better than standardization by range. However, since both are useful, the latter procedure was used so as to conform with that used on the morphological data (p. 236). The nearest-neighbour phenogram of 41 individual specimens (based on a matrix of Manhattan metric distances of the full data set) is presented in figure 44. The most sriking feature of this phenogram is the within-population heterogeneity. The Kingscote population (2) (*viz. Conn 1047*) has the Little Desert population (4) (*viz. Conn 697*) as its nearest neighbour (Fig. 44), not the American River population (1) as might be expected. However, the American River population has the Kingscote population as its second nearest neighbour. The American River population (*viz. Conn 1067*) has *Conn 694* (of the Little Desert population) as its nearest neighbour (Fig. 44). The Rankin Springs population (6) has its closest relationship with the Little Desert population (4), then to Bendigo (5), and finally with Braendler's Scrub (3).

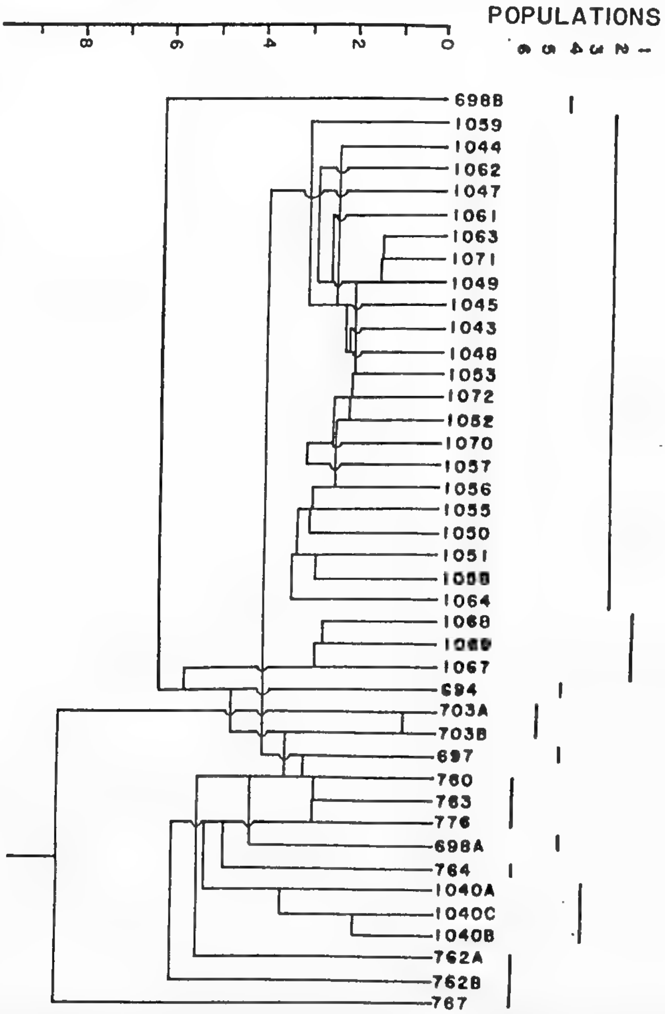


Fig. 44. Nearest neighbour phenogram generated from the Manhattan distance matrix of 41 specimens ot *P. aspalathoides* (based on the volatile leaf oils). The collection numbers given immediately above the phenogram were all collected by the author. The horizontal lines beside the phenogram group the specimens into their respective populations (for further details of populations refer Table 14).

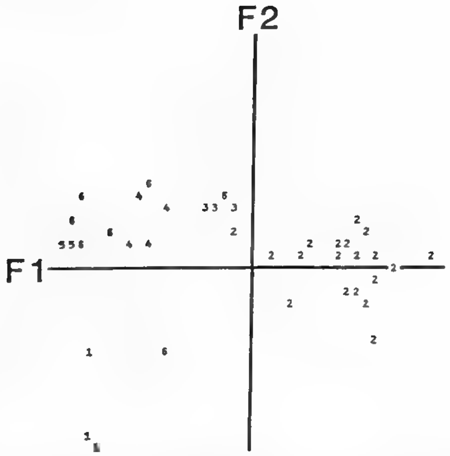


Fig. 45. Principal coordinate plot (function 1 versus function 2) of the *P. aspalathoides* populations (based on volatile leaf oils). 1 = American River; 2 = Kingscote; 3 = Braendler's Scrub; 4 = Little Desert; 5 = Bendigo; 6 = Rankin Springs. For further details of populations refer Fig. 41 and Table 14.

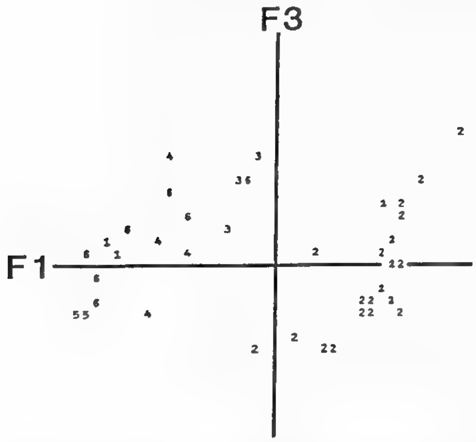


Fig. 46. Principal coordinate plot (function 1 versus function 3) of the *P. aspalathoides* populations (based on volatile leaf oils). 1 = American River; 2 = Kingscote; 3 = Braendler's Scrub; 4 = Little Desert; 5 = Bendigo; 6 = Rankin Springs. For further details of populations refer Fig. 41 and Table 14.

The first four axes of the principal coordinate analysis provide a useful simplification of the data because they account for 68.33% of the total variation. In the plots of function 1 versus function 2 (Fig. 45), and function 1 versus function 3 (Fig. 46), the Kingscote population (2) forms a distinct cluster, separate from all other populations. The American River population (1) is distinct from all populations on several functions (e.g. Fig. 45), but on others (e.g. Fig. 46) it is closely related to the mainland populations. The Rankin Springs population (6) usually forms indistinct clusters. The Bendigo population (5) has its closest relationship with the Rankin Springs population and is usually distinct from the other mainland populations (3 & 4). Overall, the mainland populations are weakly clustered on most functions such that they do not form easily separable population-based clusters.

Geographic variation of *Prostanthera aspalathoides* based on volatile leaf-oils

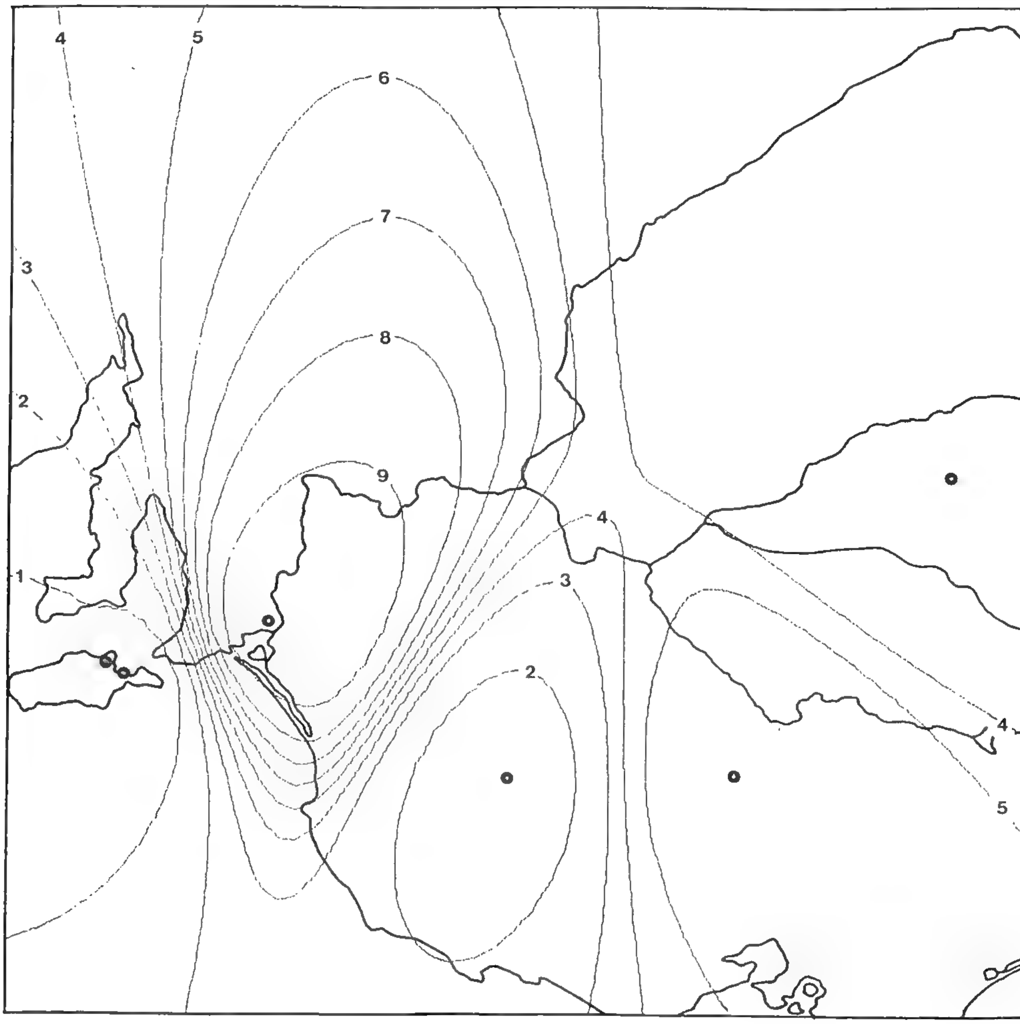
Of the original 27 characters, 18 showed both a significant *F*-test and a significant SNK test (both at the 0.01 level). Considering each character separately, there are four pattern types. One common type of pattern of geographic variation is illustrated by α - Pinene (character 1) (Fig. 47) and β - Pinene (character 2). The Braendler's Scrub population (3) is rich in α - Pinene and is significantly different with respect to this character, from all other populations. The two Kangaroo Island populations (1 & 2) have the lowest quantities of α - Pinene, whereas the other populations (4-6) have intermediate amounts.

The second common type is exemplified by the character 18 ($C_{15}H_{24}$) (Fig. 48). The Kingscote (2) and the Little Desert (4) populations are rich in this sesquiterpene but the other populations (1, 3, 5 & 6) have progressively lower amounts of this component. The monoterpene $C_{10}H_{14}O$ (character 13) has a similar pattern of geographic variation.

The third common type of pattern is a slight modification of the previous type. This type is illustrated by ρ - Cymene (character 7) (Fig. 49). The Kangaroo Island populations (1 & 2) are rich in ρ - Cymene (the Kingscote population richer). The mainland populations tending to show a combined west-east and north-south trend. That is, the Rankin Springs (6) and the Braendler's Scrub (3) populations are richer in the relevant component (e.g. ρ - Cymene, Fig. 46; character 11 - $C_{10}H_{18}$), with the Little Desert (4) and the Bendigo (5) populations having progressively smaller amounts.

The fourth common type of pattern is exemplified by character 15 - $C_{10}H_{16}O$ (Fig. 50) and Maaliol (character 21). The Kangaroo Island populations (1 & 2) are rich in the relevant component, whereas the Braendler's Scrub (3) population has significantly low amounts. The other populations (4-6) are intermediate between the previous two groups.

The composite differential formed from the 18 characters which showed both a significant *F*-test and a significant SNK test (both at the 0.01 level) is presented in figure 51. The most rapid changes occur between (i) the Kangaroo Island (1 & 2) and mainland (3-6) populations, and (ii) between the Braendler's Scrub (3) and the Victorian (4 & 5) populations.



03 05 06 04 02 01

Fig. 47. Contour map (with summary of SNK test) of % composition of α - Pinene (character 1) for populations of *P. aspalathoides*. Contour symbols and values are: 1 = 0.33; 2 = 0.80; 3 = 1.27; 4 = 1.74; 5 = 2.21; 6 = 2.68; 7 = 3.15; 8 = 3.62; 9 = 4.09.

Since the sample is very small for most populations (Table 14), interpretation of these results is difficult and by necessity must be tentative. One consequence of limited population sampling is that it is not known how representative these individuals are of the respective populations. Since chemical forms are usually merely quantitatively different (e.g. Hellyer *et al.* 1969), a larger sample improves the statistical basis for any consideration of these differences. Obviously the optimal sample size is dependent upon many factors which are possibly different for different taxa. Adams (1970b, 1972a), Hunt & von Rudloff (1974), and von Rudloff (1972a) have found that populations represented by five individuals can

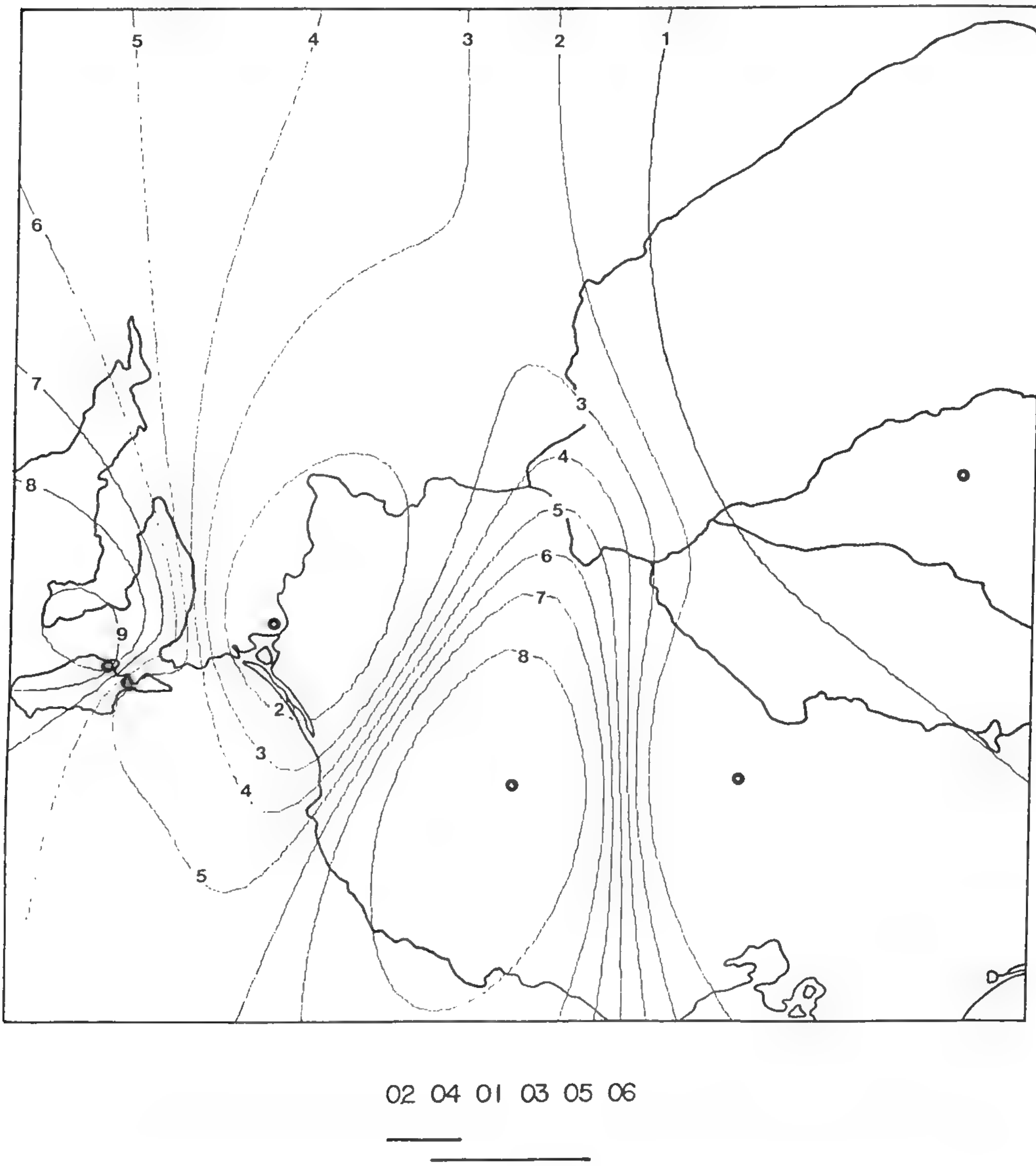
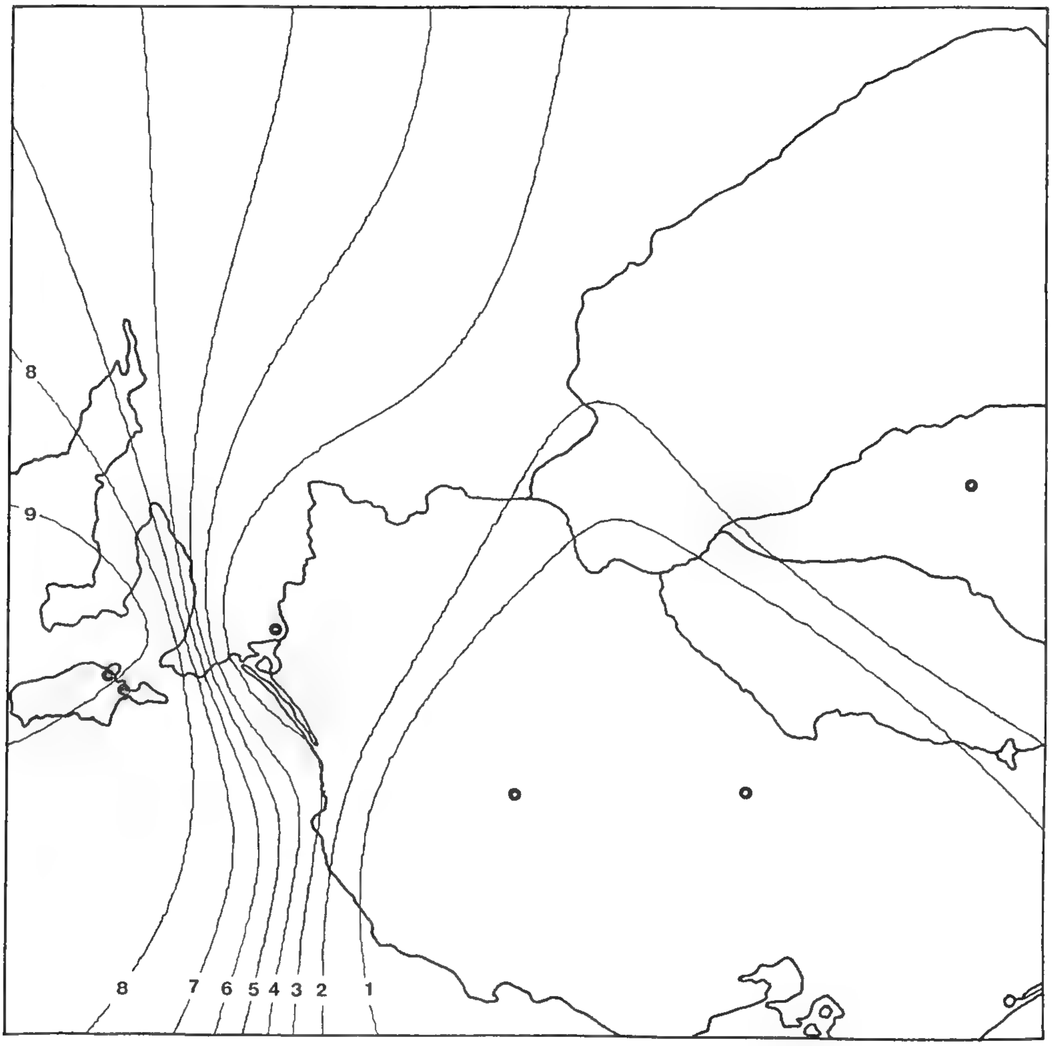


Fig. 48. Contour map (with summary of SNK test) of % composition of $C_{15}H_{24}$ (character 18) for populations of *P. aspalathoides*. Contour symbols and values are: 1 = 0.53; 2 = 0.86; 3 = 1.18; 4 = 1.50; 6 = 2.14; 7 = 2.47; 8 = 2.79; 9 = 3.11.

still show significant differences between populations. However, five individuals are more likely to represent the minimal sample size. It can be seen, for example, that five individuals probably could not adequately represent the heterogeneity of the Kingscote population (Fig. 44).

It was found that the amount of 1,8—Cineole was consistently high (mean value of 38.6% of the total composition for all populations) and is the major compound of the leaf oils. Lassak, in Althofer (1978) and Lassak (1980) also found that 1, 8—Cineole was the main component of *P. aspalathoides*. Similarly, in a preliminary study of *P. serpyllifolia* (the Mt Greenly population), I found that it was also the main component (54.4%).

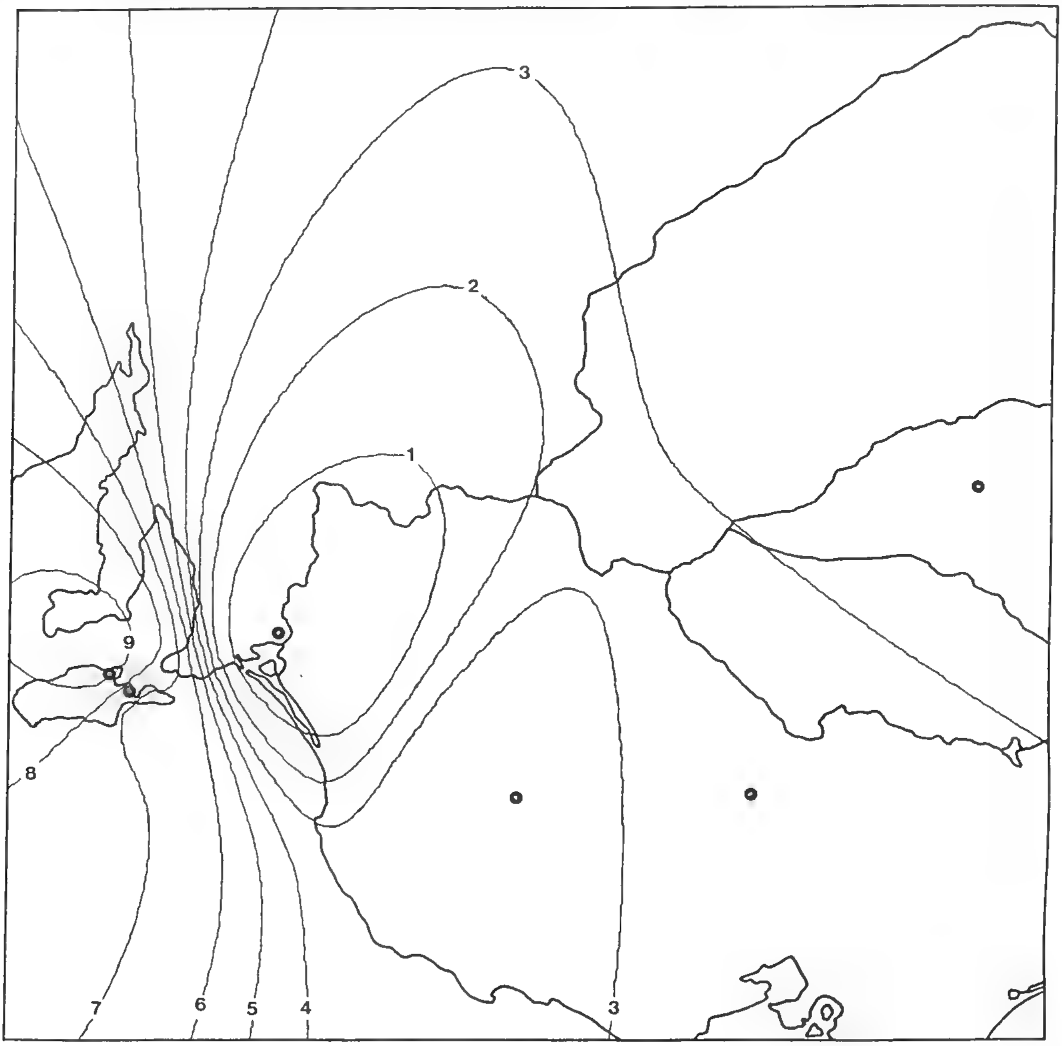


02 01 04 06 05 03

Fig. 49. Contour map (with summary of the SNK test) of % composition of ρ—Cymene (character 7) for populations of *P. aspalathoides*. Contour symbols and values are: 1 = 0.16; 2 = 0.28; 3 = 0.39; 4 = 0.51; 5 = 0.63; 6 = 0.75; 7 = 0.86; 8 = 0.98; 9 = 1.10.

The Kangaroo Island populations (1 & 2) have significantly high values of ρ—Cymene and several other monoterpenes (e.g. characters 9, 13 & 15). These populations are also rich in the two sesquiterpenes, Maaliol and character 18 (Table 13). The presence of Maaliol and ρ—Cymene is of particular interest since the specimens (from New South Wales) processed by Lassak (1980) lacked both of these compounds.

The Braendler's Scrub population (3) is characterized by significantly high values of α—and β—Pinene. However, this may be an artifact of inadequate sampling, particularly for α—Pinene, which had values ranging from 2.3 to 5.9%. Since Lassak (1980) recorded



02 01 06 03 05 04

Fig. 50 Contour map (with summary of SNK test) of % composition of $C_{10}H_{16}O$ (character 15) for populations of *P. aspalathoides*. Contour symbols and values are: 1 = 0.03; 2 = 0.09; 3 = 0.15; 4 = 0.21; 5 = 0.27; 6 = 0.33; 7 = 0.39; 8 = 0.45; 9 = 0.51.

a value of 2%, the small sample size in my study may have over-emphasized a chemical form rich in this compound, which is represented by certain individuals of the population.

To assess the extent to which the oil data supports the morphological data in explaining the pattern of geographic variation, the matrices of the Manhattan metric distances of both the leaf oil characters and the morphological characters (based on the same individuals) were compared by computing Pearson's correlation coefficient (r). The correlation coefficient for the comparison of the two matrices, based on all characters (except KHDI and STMX, refer p. 237), was only 0.3. However, a correlation coefficient of r = 0.61 resulted

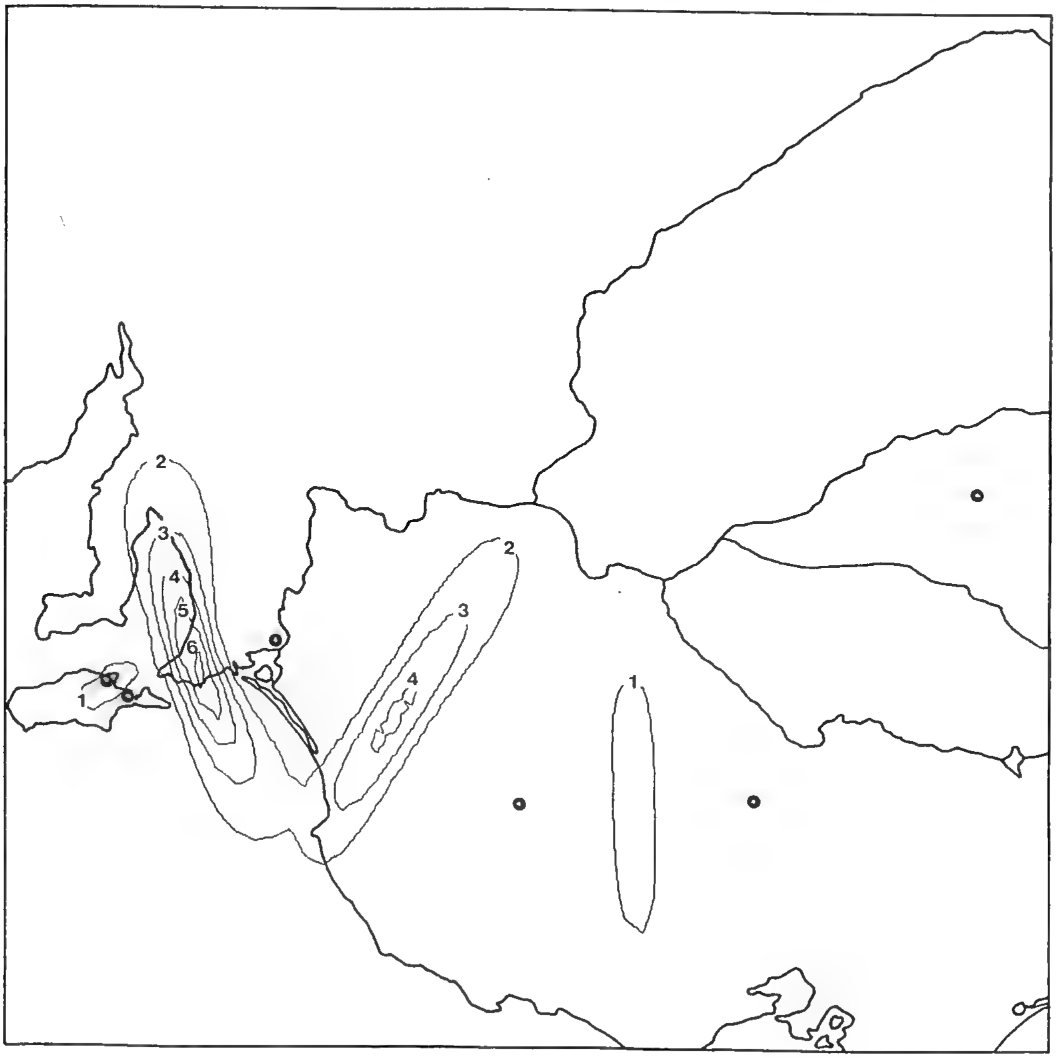


Fig. 51. The composite differential formed from volatile leaf oil compounds in populations of *P. aspalathoides*. Contour symbols and values are: 1 = 0.09; 2 = 0.15; 3 = 0.22; 4 = 0.28; 5 = 0.34; 6 = 0.40.

from the comparison of the two matrices, based on those characters which had a significant *F*-test and a significant SNK test (both at the 0.01 level). Since the chemical characters appear to be under strict genetic control (Hanover 1966a, 1966b; Forsen & von Schantz, in Bendz & Santesson 1973; von Rudloff 1972b; Irving & Adams, in Runeckles & Mabry 1973), the regions of differentiation (Figs. 26 & 51), in particular the region of rapid change between the mainland and the Kangaroo Island populations, may reflect genotypic as well as phenotypic distinctness.

Function of volatile oils in *Prostanthera*

The function of terpenoids is very inadequately known and has often been regarded as obscure. For example, Bonner (1950) assigned no function to lower terpenoids, whereas Sandermann (1962) regarded terpenoids as waste products. Contrary to the above, Fraenkel (1959) concluded that the secondary compounds (in a number of families) repelled or attracted insects. A similar view was expressed by Briquet (1895) for the Labiatae. Recent biochemical and physiological studies have shown that many terpenoids participate in the metabolism of the plant (refer Loomis, in Pridham 1967). Other studies have further established probable functions for terpenoids (e.g. Ehrlich & Raven 1965; Goodwin, in Pridham 1967; Harborne 1972 (& papers therein), 1977 (& literature cited therein), 1978 (& papers therein); Langenheim 1969, 1981; Muller 1966; Nicholas 1973; Smith 1976; and Sondheimer & Simeone 1970). However, Nicholas (1973) concluded that 'there is no established role for any monoterpene with regard to its physiological or biochemical function *within* plant tissues'. Furthermore, because of the large number of terpenoids already known, it is unlikely that every one will have a specific function (Goodwin, in Pridham 1967). Smith (1976) suggests that the terpenoids are more likely to have a collective function.

Volatile oils as a defence against animals and insects

In *Prostanthera* I have noted that the foliage (particularly of sect. *Klanderia*) is not attacked by insects nor is it usually grazed by animals (p. 224). Whether or not the high concentration of volatile oils (in leaves, stems and calyces) is a definite insect-repellant and/or is unpalatable to animals, is not known. Oh *et al.* (1967) showed that monoterpenes, which are common in *Prostanthera* (refer Table 13; also Lassak 1980), inhibit digestion in deer and sheep. It is not clear, however, whether these effects are related to palatability differences (Harborne 1977). Harborne (1977) summarizes the feeding preferences of insects with respect to the known role of various chemicals as insect attractants and/or deterrants. Monoterpenes are frequently olfactory attractants, whereas a number of sesquiterpenes are important repellents. The importance of monoterpenes as feeding repellents is not clear (Harborne 1977).

Initial analyses of *P. monticola* and *P. walteri* (both sect. *Klanderia*) indicate that both of these species have relatively low quantities of volatile leaf oils. However, the foliage of both species was not grazed and it appeared to be free from insect attack. Therefore, the amount of oil does not appear to influence insect or animal feeding preferences.

Sumimoto *et al.* (1975; as summarized in Harborne 1977) found that the chemical insect repellent of *Pinus* was present only in very small amounts. Preliminary analysis of the leaves of *P. behriana* (sect. *Prostanthera* series *Subconcavae* Benth.) show that this species either lacks volatile leaf oils or these oils occur only in trace amounts. Similar to *P. monticola* and *P. walteri*, the foliage did not appear to be affected by insects. However, this species is sometimes grazed (presumably by kangaroos and rabbits). A few other species (also of sect. *Prostanthera* series *Subconcavae* Benth.), *viz. P. baxteri*, *P. nivea*, *P. saxicola* and *P. suborbicularis*, appear to lack volatile oils (Lassak 1980). At this stage, the evidence of volatile oils conferring possible unpalatability to grazers and acting as insect repellents (for *Prostanthera*) is inconclusive.

Volatile oils and pollination

Insect pollinated flowers typically have a floral scent (Bergström, in Harborne 1978; Faegri & van der Pijl 1979; Hills *et al.* 1972; Holman & Heimermann 1973; Thien *et al.* 1975). However, the flowers of sect. *Prostanthera* (which are insect pollinated) (p. 221) appear to lack floral odour (at least to human senses). I have noted that a number of species in this section (in particular *P. ovalifolia* and *P. lasianthos*) readily volatilize their essential oils, especially when in flower. It seems likely that the essential oils of the leaves, branches and calyces (in particular, the monoterpenes) may act as a general olfactory attractant which guides insects to the scentless flowers. However, until the presence or absence of floral odours in *Prostanthera* is verified using techniques similar to those of Bergström (in Harborne 1978) or Holman & Heimermann (1973), it is difficult to assess the importance of essential oil volatilization in relation to pollination. Since insects are extremely sensitive to small concentrations of volatile substances, 'flower odours are probably effective at relatively low concentrations' (Harborne 1977).

Systematic treatment

The following circumscription of *Prostanthera* section *Prostanthera* is based on the work of Bentham (1870). This brief description is offered so that the diagnostic features of the two sections can be more readily compared (refer Figs 52 & 53).

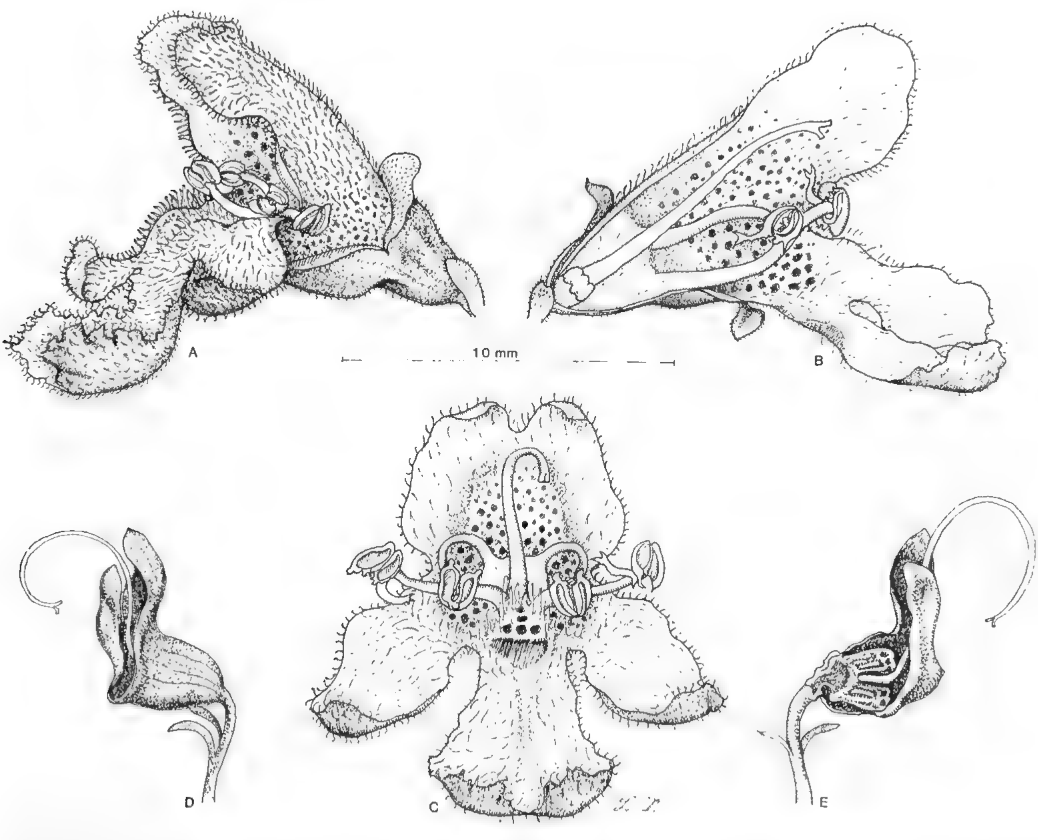


Fig. 52 *Prostanthera lasianthos.*—A. flower; B. open flower with half of calyx and corolla removed; C. distal view of corolla, androecium (after anthesis), style and stigma; D. calyx after fertilization; E. part of calyx removed to show two mericarps and style (all from cultivated material, Burrendong Arboretum).

a. *Prostanthera* Labill. sect. *Prostanthera*

Prostanthera Labill. sect. *Prostanthera*: Benth., Fl. austral. 5 (1870) 93 [as sect. '*Euprostanthera*']; Briq., in Engl. & Prantl, Nat. Pflanzenfam. 4, 3a (1895) 220 [as sect. '*Euprostanthera*']; C. Moore, Handb. fl. New S. Wales (1893) 350 [as sect. 'I'];—*Type species*: *Prostanthera lasianthos* Labill.

Calyx tube striate, lobes unequal in length. *Corolla tube* short, broad distally; *abaxial lobe* longer and more spreading than the erect adaxial lobes. *Fruit* with 4 mericarps enclosed by inward folded abaxial calyx lobe; adaxial calyx lobe usually recurved. Fig. 52.

Note: This section contains approximately 80 species. Although it is in need of revision, a systematic account is not included in this study.

b. *Prostanthera* Labill. sect. *Klanderia*

Prostanthera sect. *Klanderia* (F. v. Muell.) Benth., Fl. austral. 5 (1870) 105; C. Moore, Handb. fl. New S. Wales (1893) 352 [as sect. 'II']. *Klanderia* F. v. Muell., Linnaea 25 (1852) 426; Walpers, Ann. bot. syst. 5 (1858) 667;—*Type species*: *Prostanthera chlorantha* (F. v. Muell.) Benth.

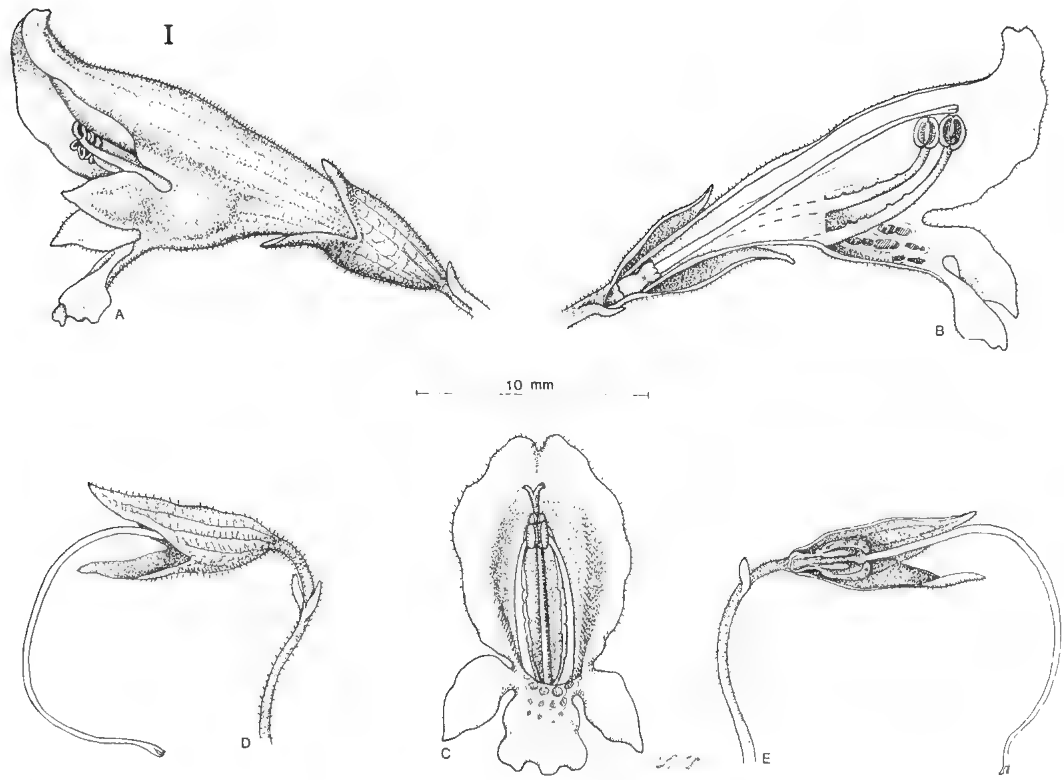
Prostanthera sect. *Cryphia* (R. Br.) Briq., in Engl. & Prantl. Nat. Pflanzenfam. 4, 3a (1895) 220; *Cryphia* R. Br., Prodr. 1 (1810) 508; Poir., in F. Cuvier (Ed.), Dict. sci. nat. 2nd ed. 12 (1819) 78; Sprengel, Linn. Syst. veg. ed. 16, 2 (1825) 704; Gen. pl. 2 (1831) 468; Benth., Labiat. gen. spec. (1834) 448; G. Don, Gen. hist. 4 (1837-8) 798; Endl., Gen. 8 (1838) 621; D. Dietr., Syn. pl. 3 (1842) 354; Walpers, Rep. bot. syst. 3 (1844) 764; *ibid* 3 (1845) 985; Benth., in DC., Prodr. 12 (1848) 558—Based on:—*P. serpyllifolia* (R. Br.) Briq. and *C. microphylla* R. Br.

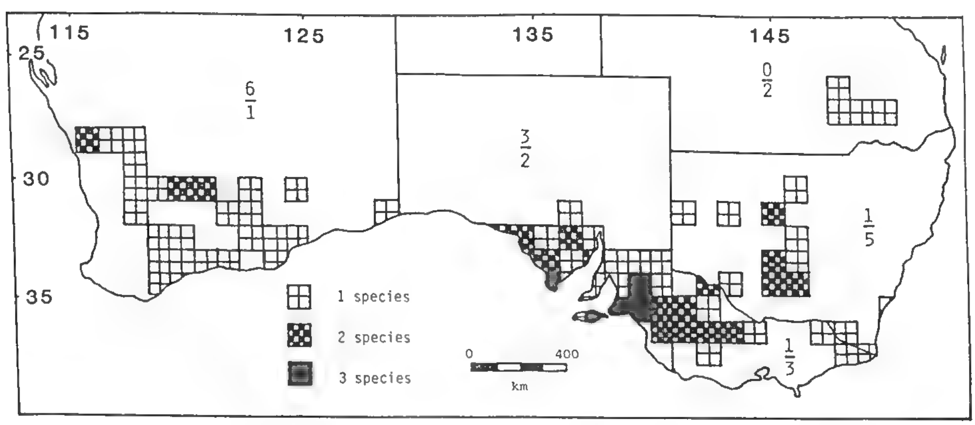
Small shrubs, up to c. 2 m high, diameter up to 1 (-1.5) m. *Leaves* with margin ± entire; venation usually not visible, sometimes faint. *Inflorescence* racemiform on leafy branches, uniflorescence monadic; prophylls 2. *Calyx* with 2 ± equal lobes, margin entire. *Corolla* glabrous basally on outer surface, at least on that part enclosed by the calyx; *tube* long, ± straight to incurved, gradually expanded distally, mouth ± elliptic in outline, 4-8 mm wide along shortest axis, inner surface glabrous; *median adaxial* and *abaxial lobes* usually ± equal in length, usually ovate to obovate, apices often rounded, abaxial lobe slightly recurved to reflexed, adaxial lobe extended forward, sometimes recurved to reflexed near apex, concave in section; *lateral lobes* usually shorter than median lobes, ± triangular, spreading to reflexed, apices usually subacute to obtuse. *Stamens* 4; filaments ligulate to subterete, glabrous; anthers basifixed between lobes, 1-2.5 mm long, introrse, connective with small fringe at distal end of filament. *Disc* up to 1 mm long, diameter up to 1.5 mm. *Pistil* glabrous; ovary ± cylindrical-ovoid to obovoid, 4-lobed, lobes 0.1-0.3 mm long, enlarging after fertilization; style terminal, slender, ligulate to terete; slightly curved, lying next to inner adaxial surface of corolla; stigma shortly bifid. *Fruit* of 4 mericarps, mericarps not enclosed by calyx lobes; seed ± flattened, ellipsoid to oblong-ellipsoid, rarely subcylindrical, slightly incurved, 1-2.5 x 0.5-0.8 x 0.2-0.5 mm, thickened distally. Fig. 53.

Recognised taxa and their distribution

In this revision fifteen species are recognized in sect. *Klanderia* (*viz. P. aspalathoides*, *P. calycina*, *P. chlorantha*, *P. florifera*, *P. grylloana*, *P. incurvata*, *P. laricoides*, *P. monticola*, *P. patens*, *P. pedicellata*, *P. porcata*, *P. ringens*, *P. semiteres*, *P. serpyllifolia* and *P. walteri*). *Prostanthera* sect. *Klanderia* occurs in all mainland States of Australia (except the Northern Territory), but is absent from Tasmania (Fig. 53-II). The number of species of sect. *Klanderia* which occur in each State are: Queensland 2; New South Wales 6; Victoria 4; South Australia 5; and Western Australia 7. *P. serpyllifolia* ssp. *serpyllifolia* is confined to South Australia, whereas *P. serpyllifolia* ssp. *microphylla* occurs in New South Wales, Victoria, South Australia and Western Australia. *P. grylloana*, *P. incurvata*, *P. laricoides*, *P. patens*, *P. pedicellata* and *P. semiteres* are confined to Western Australia. *P. calycina*, *P. chlorantha* and *P. florifera* are confined to South Australia. *P. aspalathoides* occurs in all eastern mainland States plus South Australia. *P. monticola* and *P. walteri* occur in New South Wales and Victoria. *P. ringens* occurs in Queensland and New South Wales. *P. porcata* is restricted to south-eastern New South Wales.

I





II

Fig. 53. Floral structure and species diversity of *Prostanthera* sect. *Klanderia*. I. *Prostanthera aspalathoides*.— A. flower; B. open flower with half of calyx and corolla removed; C. distal view of corolla, androecium, style and stigma, as seen from abaxial side; D. calyx after fertilization; E. part of calyx removed to show two mericarps and style (all *Conn 3307*). II. Species diversity of *Prostanthera* sect. *Klanderia* (number of species per 1° square).— above the hyphen the endemic species for each State, below the hyphen the non-endemic species.

Key to species

1a. Inner surface of calyx hairy, may be sparsely so, or if glabrous then pedicel* at least 9 mm long with branches glabrous and densely glandular; and corolla red 2

1b. Inner surface of calyx glabrous, sometimes with a few hairs near margin 8

2a. Leaves 5-13 mm long; lamina 15-50 mm long; corolla 30-35 mm long; prophylls 10-18 mm long (New South Wales, Victoria) .... 13. *P. monticola*

2b. Leaves up to 2.5 (-3) mm wide; lamina up to 20 mm long; corolla 12-27 mm long; prophylls 2 (-2.5) mm long (Western Australia) 3

3a. Outer surface of calyx hairy throughout (sometimes sparsely so) 4

3b. Outer surface of calyx glabrous or if hairy, then hairs restricted to distal part of calyx and then sparsely so 7

4a. Anther appendage absent; inner surface of calyx sparsely hairy; branches glabrous; pedicel* 7-13 mm long .... 7. *P. pedicellata*

4b. Anther appendage present; inner surface of calyx densely hairy; branches hairy (usually densely so); pedicel less than 3.5 mm long 5

5a. Leaves spathulate, conduplicate .... 12. *P. grylloana*

5b. Leaves ± terete or ovate to oval; margin recurved so lamina often appearing oblong, never conduplicate 6

6a. Leaves less than 2 mm long; lamina length to width ratio less than 2; calyx lobes length to tube ratio greater than 0.5 .... 3. *P. patens*

6b. Leaves at least 10 mm long; lamina length to width ratio (6-) 12-32; calyx lobes length to tube ratio less than 0.45 .... 10. *P. laricoides*

7a. Branches hairy, sometimes restricted to two opposite lines along branches (rarely glabrous); pedicel up to 1.5 (-2) mm long; leaves usually incurved .... 8. *P. incurvata*

7b. Branches glabrous (rarely with an occasional hair); pedicel 3-15 mm long; leaves ± straight to slightly recurved .... 9. *P. semiteres*

8a. Prophylls inserted at base or on lower half of pedicel; [anthopodium to a_1 axis ratio (1-) 2-7] (Queensland, New South Wales) .... 11. *P. ringens*

8b. Prophylls inserted at base of calyx or on upper half of pedicel; [anthopodium to a_1 axis ratio usually less than 1] 9

9a. Hairs irregularly ramose, ± densely covering branches, leaves, pedicels and calyx (simple hairs may also be present) (South Australia) .... 1. *P. chlorantha*

9b. Hairs simple, sometimes with a few ramose hairs on calyx (Kangaroo Island populations of *P. serpyllifolia* ssp. *microphylla*), never on branches or leaves 10

10a. Hairs (of branches, leaves—particularly on margin and midrib of abaxial surface and calyx) stiff, straight, appressed; hair apex directed towards distal part of organ (Eyre Peninsula, South Australia) .... 4. *P. calycina*

10b. Hairs (of branches, leaves and calyx) ± soft, recurved to reflexed, never appressed, frequently curled (widespread) 11

11a. Leaves ± terete to linear-obovate 12

11b. Leaves ovate to narrowly ovate, sometimes suborbicular, never terete or linear-obovate 13

12a. Anther appendage 1-2.5 mm long; calyx 7-12 mm long (Gawler Ranges, South Australia) .. 6. *P. florifera*

12b. Anther appendage up to 0.3 (-0.5) mm long; calyx 5-7 mm long (widespread, absent from Gawler Ranges) .... 5. *P. aspalathoides*

13a. Branches quadrangular and 4-ridged, ridges adnate to base of petiole (SE New South Wales) .. 15. *P. porcata*

13b. Branches ± terete, ridges absent 14

14a. Lamina (10-) 18-26 (-38) x 5-15 (-17) mm; petiole 2-5 (-8) mm long; venation faint; abaxial median corolla lobe 5-10 mm long; lateral corolla lobes (4-) 5-7 (-10) mm long (SE New South Wales and eastern Victoria) .... 14. *P. walteri*

14b. Lamina (1-) 1.5-13 x 0.5-4 (-6) mm; petiole absent or 0.4-2.5 (-5) mm long; venation not visible; abaxial median corolla lobe 3-4 mm long; lateral corolla lobes 1-4.5 mm long (widespread; in Victoria N & W of Great Dividing Range) .... 2. *P. serpyllifolia*

* Pedicel = a_1 axis + anthopodium

1. **Prostanthera chlorantha** (F.v. Muell.) F.v. Muell. ex Benth., Fl. austral. 5 (1870) 108; F.v. Muell., Fragm. 9 (1875) 162; *op. cit.* 10 (1876) 18; Woolls, Pl. New S. Wales (1885) 83; F.v. Muell., Key Vict. pl. 1 (1885) 42; *op. cit.* 1 (1887) 386; Tate, Trans. & Proc. Roy. Soc. S. Austral. 12 (1889) 111; Handb. fl. extratrop. S. Austral. (1890) 151, 252; C. Moore, Handb. fl. New S. Wales (1893) 353; Briq., in Engl. & Prantl, Nat. Pflanzenfam. 4, 3a (1895) 220; Dixon, Pl. New S. Wales (1906) 232; Guilfoyle, Austral. pl. (1911) 302; J.M. Black, Fl. S. Austral. ed. 1, 3 (1926) 492; *op. cit.* ed. 2, 4 (1957) 739, t. 1058; Hj. Eichler, Suppl. Black's fl. S. Austral. (1965) 269; Galbraith, Wildfl. SE. Austral. (1977) 326; Althofer, Cradle of Incense (1978) 124, 128, 129.

Lectotype (here chosen): *Fischer s.n.*, -.?xi.1851, '*Prostanthera coccinea* ferd. Mueller var. *chlorantha*. Mount Barker Creek.', South Australia (MEL 41908—lower left specimen; isolecto. MEL 41908—upper and centre right specimens, probable isolecto. K, MEL 41906, MEL 41907). [refer Typification].

Klanderia chlorantha F.v. Muell., Linnaea 25 (1852) 426; Walpers, Ann. bot. syst. 5 (1858) 667.

Small shrub, up to 0.5 (-1) m high. *Branches* ± terete, hairy; hairs ramose, with occasional simple hairs, 0.1-0.4 mm long; sparsely glandular. *Leaves* mostly arranged along short side branches, hairy; hairs ramose; *petiole* absent or if present, then less than 0.5 mm long; *lamina* suborbicular to broad-ovate, 1-3 (-4) x 1-2.5 (-3) mm [lamina length to width ratio 1-1.8; distance of maximum width from base to total lamina length 0.1-0.35]; base rounded; margin entire, strongly recurved especially towards base and so lamina appearing deltoid; apex obtuse to rounded; venation not visible to indistinct. *Pedicel* 5-13 mm long, slender, often glabrous basally, glabrescent for much of its length, distally with ramose hairs, sparsely glandular; *prophylls* inserted 0.5-3 mm from distal end of pedicel and so, usually not or occasionally just, overlapping basal part of calyx (sometimes alternately arranged), ± linear-obovate 1-2 x c. 0.5 mm long, slightly concave; abaxial surface and margin hairy (hairs ramose) and lepidote; adaxial surface glabrous; apex obtuse. *Calyx* 8-12 mm long, green, often with red-purple ribs (streaks), especially on tube; outer surface ramosely tomentose and lepidote; inner surface glabrous; *tube* 5-6 mm long; *lobes* triangular, 3-6 mm long, 2-4 mm wide at base; apex acute. *Corolla* 15-25 mm long, mauve, blue-green, dusty green-red to green-yellow with a pink tinge; outer surface sparsely hairy distally; hairs simple, c. 0.1 mm long; inner surface lacking dark spots, glabrous; *tube* 10-25 mm long; *abaxial median lobe* obovate, 2-5 mm long, c. 2 mm wide at base, slightly recurved; margin ± entire to slightly irregular; apex obtuse to rounded, often emarginate; sinus up to 0.2 mm long; *lateral lobes* oblong-ovate, 4-5 mm long, c. 2 mm wide at base; margin entire, apex subacute; *adaxial median lobe-pair* suborbicular to broad-ovate, 5-10 mm long, c. 10 mm wide at base, slightly recurved distally; margin entire; apex rounded, sometimes emarginate; sinus up to 0.5 mm long. *Stamens* inserted c. 10 mm above base of corolla; filaments c. 5 mm long, with minute broad-triangular glandular trichomes; anthers 1.5-2 mm long; base of lobes minutely acuminate with acumen c. 0.1 mm long; apex obtuse to minutely acuminate, although appendage appearing absent, one side of connective usually slightly extended to form a minute basal appendage up to 0.03 mm long, sometimes with minute broad-triangular trichomes on appendage. *Pistil* 17-22 mm long; ovary c. 0.5 mm long, diameter c. 1 mm at base, lobes small, c. 0.1 mm long; style 15-18 mm long; stigma lobes up to 1 mm long. *Mericarps* 2-3 mm long, c. 1 mm wide distally, distally 0.4-0.6 mm extended beyond base of style. Figs 54 & 55.

Typification

The herbarium sheet MEL 41908 contains five specimens and two envelopes of fragments. The herbarium label (in Mueller's hand) corresponds with the locality details given in the protologue ('In montibus altis petraeis juxta amnem Mount-Barker-creek

sitis flumen Bremer versus . . . Fischer'; Mueller 1852, p. 426). There is close agreement between the brief description provided in the protologue and the lower left specimen of MEL 41908. Since Bentham examined this sheet (initials on label and on one envelope of fragments) this provides additional support for selecting a specimen from this sheet.

Distribution

South Australia—Murray Mallee, Mt Lofty Block (incl. Kangaroo Island), Southern Highlands and Plains [Eyre Peninsula].

Conservation status

This species appears to be conservationally endangered—Risk code = 3V, ?C.

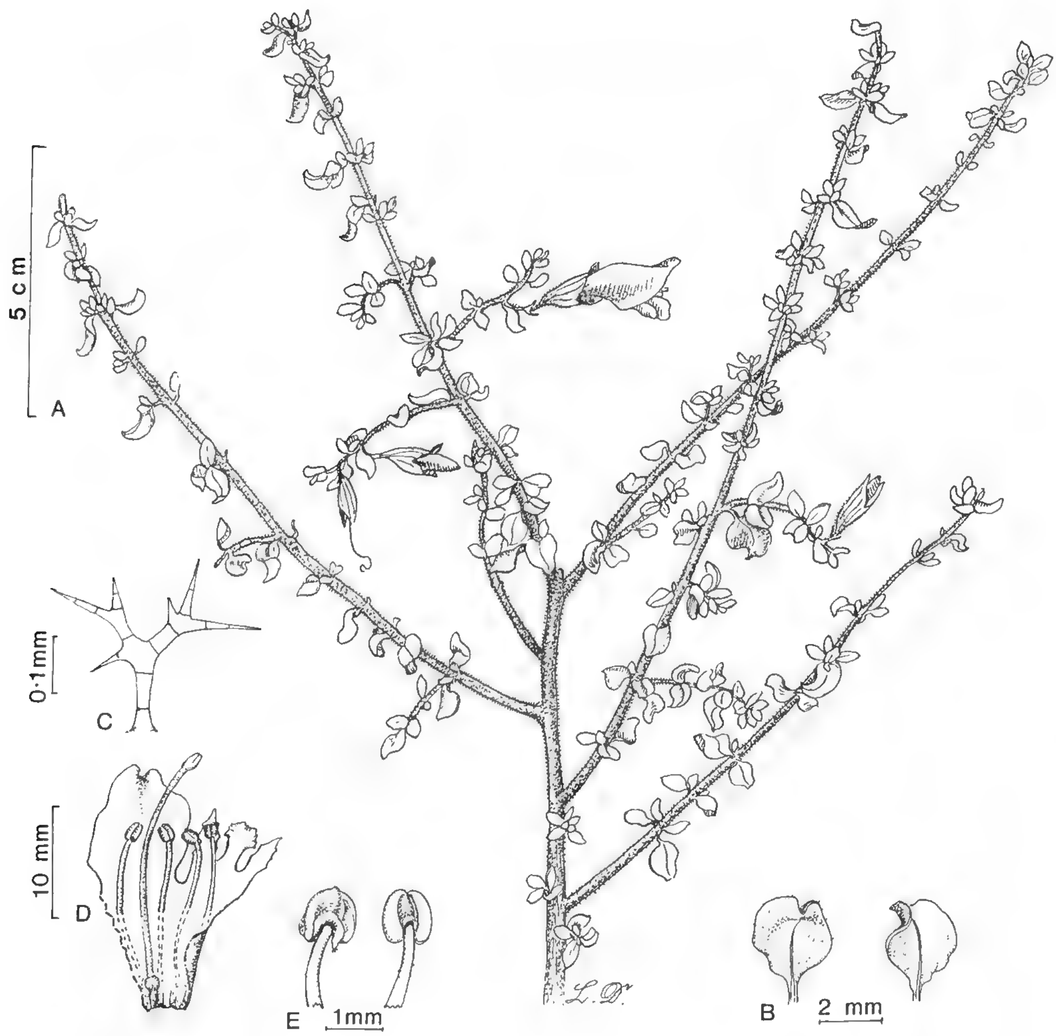


Fig. 54. *Prostanthera chlorantha*.—A. twig and flowers; B. detail of leaves; C. irregularly branched hair; D. open corolla; E. stamens—ventral and dorsal views (all *Conn 811*).

Ecology

This species forms small populations of a few scattered plants, on sandy and loamy soils. It is commonly associated with *Banksia*, *Daviesia*, *Comosperma*, and *Leptospermum* shrubland.

Notes

This species is readily identified by the presence of irregularly branched hairs. *P. serpyllifolia* ssp. *microphylla* (from Kangaroo Island) is the only other taxon which has similar indumentum. However, the latter taxon has fewer branched hairs than those of *P. chlorantha*. Furthermore, in spp. *microphylla* the branched hairs only occur on the calyx. Other features including habit and leaf shape, suggest close affinities between these two taxa.

Common name: Green mint-bush (Ewart 1930)

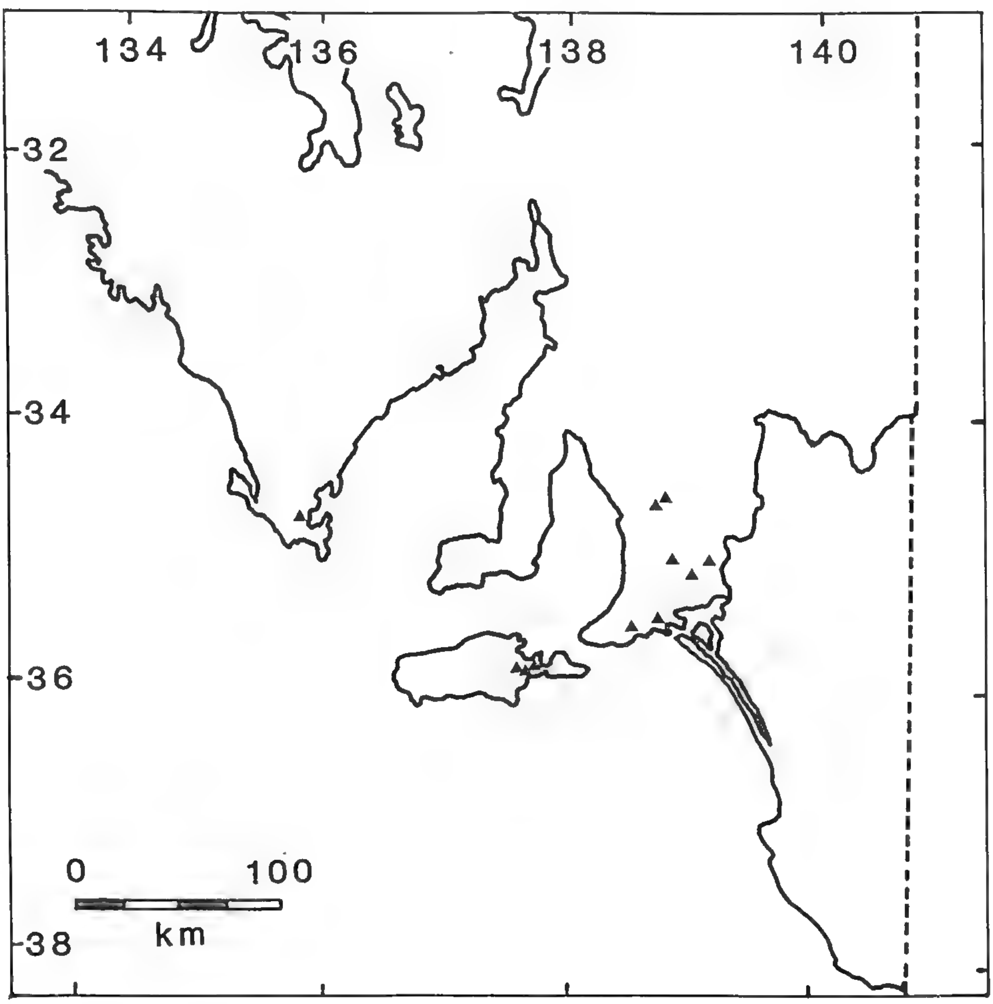


Fig. 55. Distribution map of *Prostanthera chlorantha*.

Selected specimens examined (c. 60 collections)

SOUTH AUSTRALIA.—Murray Mallee (Goolwa): *Hunt 2649*, 16.vii.1966, near Currency Creek, on main Goolwa to Strathalbyn road (AD). Mt Lofty Block: Peninsula Uplands (Barossa): *Purdie 83*, 4.ix.1966, back of Barossa Reservoir (AD); (Para): *Ising s.n.*, -.x.1920, Para River near Gawler (AD); (Hahndorf): *Cleland s.n.*, 18.ix.1965, back road from Harrogate to Monarto (AD); (Sandergrove): *Ising s.n.*, -.vi.1925, Kinchina (AD); Scotts Hill): *Mueller s.n., s. dat.* Mt Barker Creek (MEL 41903-41905); (Inman Valley): *Carrick 2959-2964*, 21.x.1971, Victor Harbor (AD): Kangaroo Island (Mt Marsden): *Rogers s.n.*, -.ix.1908, Retta's Lagoon (NSW); (Cygnet): *Eichler 15262*, 6.xi.1958, c. 13 kms S of Kingscote (AD); (Amberley): *P. Wilson 889*, 13.xi.1958, near Birchmore Lagoon (AD); (MacGillivray): *Carrick 3509*, 9.xi.1973, Kingscote Council Sand Reserve, near MacGillivray (AD). —[Eyre Peninsula] Southern Highlands and Plains (Lincoln): *Dixon s.n. in herb. Tate*, -.x.1883, Port Lincoln (AD 96928849).

2. **Prostanthera serpyllifolia** (R. Br.) Briq., in Engl. & Prantl, Nat. Pflanzenfam. 4, 3a (1895) 220. *Cryphia serpyllifolia* R. Br., Prodr. (1810) 508.

Type: *R. Brown s.n.* [*J.J. Bennett 2360*], *anno* 1802-5 [22.ii.1802 (R. Br. MSS.—microfilm copy at AD)], South Coast, Bay IX (also refer R. Br. MSS.) [Memory Cove (Stearn 1960)], southern Eyre Peninsula, South Australia (BM *n.v.*; probable duplicates in BRI, E, K, MEL 43408—left specimen, P, S). [refer Typification, p. 293; for full synonomy see ssp. *serpyllifolia*.

Small shrub, prostrate to erect, up to 0.5 (-1.6) m high. *Branches* ± terete, often slightly flattened distally, moderately to densely hairy, hairs (0.09-) 0.1-0.4 (-0.5) mm long, white; glandular; glands hemispherical, 1-35 (-90) glands/mm², rarely eglandular. *Leaves* sparsely to densely hairy, occasionally glabrous, sparsely to densely glandular; glands sunken in pits or raised and hemispherical; *petiole* absent or if present, then up to 1.5 (-3) mm long; *lamina* ovate to broadly elliptic (rarely suborbicular), to oblong-ovate, (1-) 1.5-13 x (0.5-) 0.7-4 (-6) mm, [length to width ratio (1-) 1.3-4 (-5.5), length of maximum width from base to total lamina length (0.07-) 0.2-0.6 (-0.7)]; base subattenuate to rounded; margin entire, recurved; apex obtuse to rounded; venation indistinct; base of midrib sometimes slightly raised on abaxial surface, sometimes slightly sunken on adaxial surface. *Pedicel* (0.8-) 1-5 (-13) mm long, ± terete, green or maroon, glabrous or hairy; hairs (when present) 0.09-0.4 (-0.5) mm long, white; *prophylls* inserted at base of calyx (rarely up to 1 mm from base of calyx), hence overlapping base of calyx, narrow-obovate to ± oblong, (1.1-) 2-4 (-5.3) x (0.3-) 0.5-0.8 (-1) mm [length to width ratio (2.5-) 3-7.5 (-12)], slightly concave, often recurved distally, rarely reflexed, glabrous or sparsely to densely hairy; hairs often restricted to margin; margin entire, usually slightly recurved; apex obtuse. *Calyx* (4.3-) 5-12 mm long, maroon or green; outer surface glabrous, or with a few scattered hairs to densely hairy; hairs white, sparsely to densely glandular; glands hemispherical; inner surface glabrous; *tube* 3-6 (-7) mm long; *lobes* ± broad-triangular, 1.5-4.5 (-5) mm long, 4-6 mm wide at base; margin entire; apex ± obtuse to rounded. *Corolla* 15-22 mm long, pink to mid-red, mid (metallic) blue-green, occasionally yellow; inner surface paler than outer surface; outer surface glabrous at base, sparsely to densely hairy distally, inner surface glabrous; *tube* 9-17 mm long; *abaxial median lobe* ± oblong-triangular to ± obovate, 3-4 mm long, ± recurved to reflexed; margin entire; apex obtuse to broadly rounded (when obovate), often emarginate; sinus up to 0.8 mm long; *lateral lobes* ± ovate to triangular, often narrowly so, sometimes obovate, 1-4.5 mm long, ± recurved to reflexed; margin entire, sometimes irregular distally; apex obtuse to subacute; *adaxial median lobe-pair* broadly triangular, 5-6.5 mm long, slightly incurved basally, often recurved distally; margin entire; apex obtuse, often slightly emarginate; sinus up to 0.3 (-0.5) mm long. *Stamens* inserted c. 8.5-9 mm from base of corolla; filaments c. 5.5-9 mm long, with a few glandular trichomes; anthers 1-2 mm long; base of lobes with a minute acumen up to 0.1 mm long; connective basally extended to form 1 or 2 short appendages (0.1-) 0.4-1.4 mm long, appendage rarely absent. *Pistil* 20-24 mm long; ovary 0.5-0.8 mm long, diameter at base 0.6-1 mm, lobes small, c. 0.1 mm long; style 19-23 mm long; stigma lobes up to 0.5 mm long. *Mericarps* 1.5-1.7 mm long, distally 0.5 mm extended beyond base of styles. Figs 56-58.

Typification

Brown (1810) does not cite any specimens for *Cryphia serpyllifolia* in the protologue. The locality is imprecisely cited as '(M)' [Ora Meridionalis—the South coast from Cape Leeuwin, Western Australia, to the islands of Bass Strait and Wilson's Promontory, Victoria (Stearn 1960)]. As pointed out by Burbidge (1956), such imprecise localities are useless for the determination of type localities. However, in Brown's MSS (microfilm copy held at AD, also refer Burbidge 1955), he cites the locality as 'Bay IX' [Memory Cove (Burbidge 1956; Stearn 1960)] and the date of collection as 'Feby. 22. 1802'.

Stearn (1960) gives a detailed account of the Brown herbarium. He suggests that it is best to select as the 'lectotype of a Brownian species the most complete individual specimen in the British Museum annotated by Brown . . . '. Therefore, I have delayed the choosing of a lectotype until I have examined Brown's material in the British Museum (see p. 211). J. Carrick (*in adnot.*) mentions a number of specimens held at BM (which I have not examined) which could be referable to the type. Of these, 'Brown 2360. Cryphia serpyllifolia, Bay IX South Coast' seems likely to be part of the original collection.

Distribution

Toowoomba, Queensland (Bailey 1901); New South Wales—Central Western Slopes, South Western Plains; Victoria—western Northern Plains, Mallee; South Australia—Murray Mallee, Mt Lofty Block (incl. Kangaroo Island), Yorke and Eyre Peninsulas; and Western Australia—south-eastern Eremaean, and South West.

Conservation status: considered not at risk.

Ecology

This species frequently occurs in Mallee communities, particularly on loamy and sandy soils which are overlying and associated with calcarenite (limestone), frequently with outcrops of calcrete.

Key to subspecies

1a. Lamina 4-13 x 1-4 (-6) mm, ± flat (straight), usually not recurved or reflexed, leaves not clustered; petiole 0.4-1.5 (-3) mm long; pedicel 3-15 mm long; calyx (6-) 8-12 mm long .... 2.1 ssp. *serpyllifolia*

1b. Lamina (1-) 1.5-3 (-3.5) x 0.5-1 (-1.5) mm, recurved to reflexed and/or majority of foliage occurring on short lateral axes so that leaves appearing clustered; petiole absent or up to 0.3 (-0.5) mm long; pedicel 0.7-2.5 (-5) mm long; calyx (4.3-) 5-7.5 (-9.5) mm long2.2 ssp. *microphylla*

2.1 ssp. serpyllifolia

Cryphia serpyllifolia R. Br., Prodr. (1810) 508; Sprengel, Linn. Syst. veg. ed. 16, 2 (1825) 704; G. Don, Gen. hist. 4 (1837) 798; Walpers, Rep. bot. syst. 3 (1844) 764; Benth., Labiat. gen. spec. (1834) 448; in DC., Prodr. 12 (1848) 588. [Refer Typification above].

P. serpyllifolia (R. Br.) Briq., in Engl. & Prantl. Nat. Pflanzenfam. 4, 3a (1895) 220; J.M. Black, Fl. S. Austral. ed. 1, 3 (1926) 492; *op. cit.*, ed. 2, 4 (1957) 739; Galbraith, Wildfl. SE. Austral. (1977) 325; Althofer, Cradle of Incense (1978) 146, 153.

P. coccinea F. v. Muell., [Sec. gen. report veg. colony (Oct. 1854) 13, *nom. nud.*] Trans. Phil. Soc. Victoria 1 (1855) 48, *p.p.*; J. Bot. Kew gard. misc. 8 (1856) 168, *p.p.*; Fragm. 6 (1868) 108, *p.p.*; *op. cit.* 9 (1875) 162, *p.p.*

Lectotype (here chosen): *Anon. s.n., s. dat.*, 'Prope m. Dutton. Fruticul. humil. diffus.', southern Eyre Peninsula, South Australia (MEL 43386). Other probable syntype: *Anon. s.n., s. dat.*, 'Near Spencers Gulf' (MEL 43876). [refer Typification, p. 295].

Branches moderately to densely hairy, 26-200 (-272) hairs/mm^2; hairs (0.1-) 0.15-0.4 (-0.5) mm long, recurved to reflexed. *Leaves* arranged along the axis and branches, not clustered along short axes, sparsely to moderately hairy, often glabrous; hairs similar to

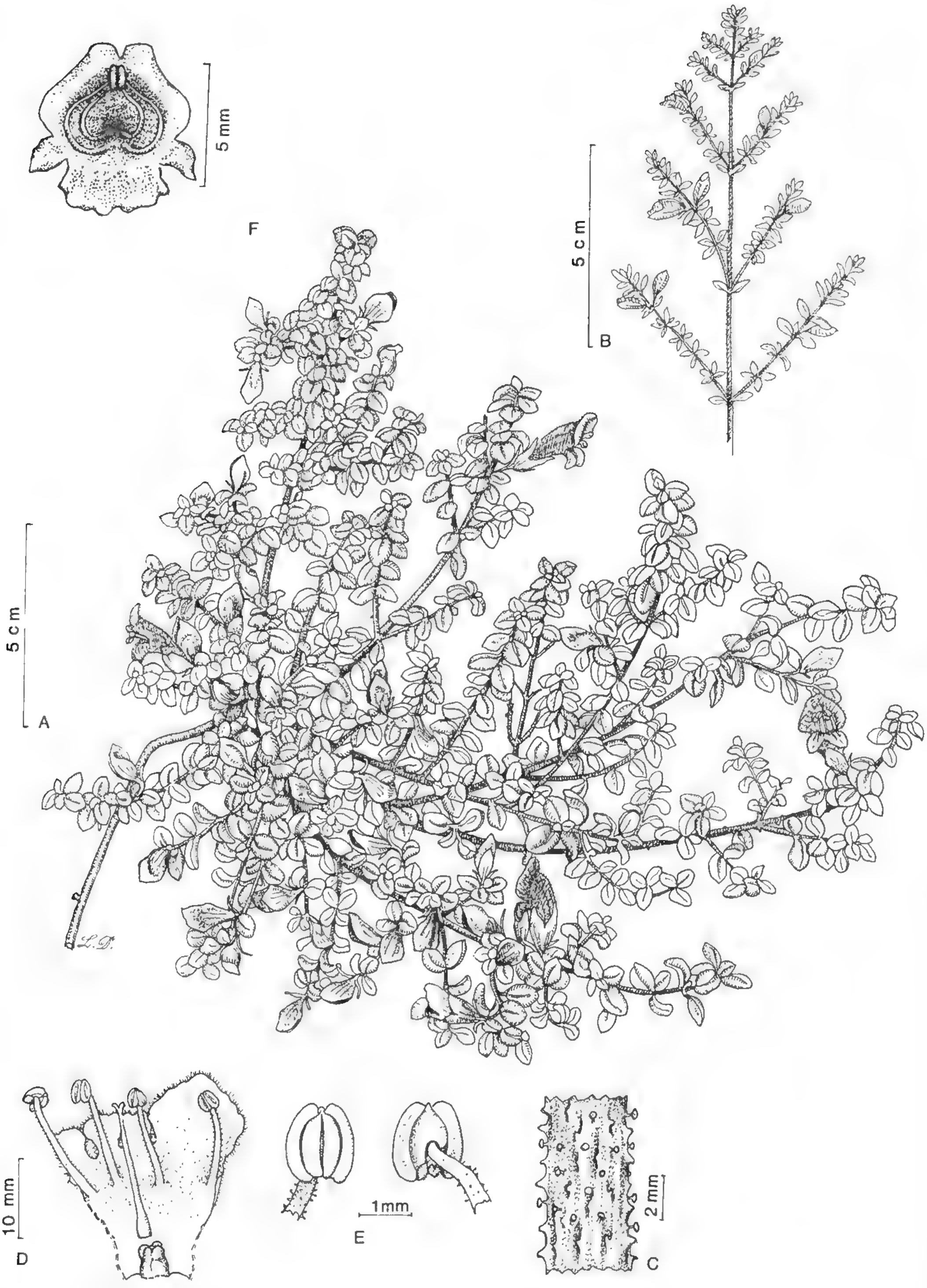


Fig. 56. *Prostanthera serpyllifolia* ssp. *serpyllifolia*. A. twig and flowers (*Jackson 2641*); B. twig and flowers (*Tindale 589*); C. glandular trichomes of branch; D. open corolla; E. stamens—ventral and dorsal views (*Jackson* 2641); F. distal view of corolla and androecium, gynoecium removed (*Carrick 3911A*).

those of branches; *petiole* 0.3-1.5 (-2) mm long; *lamina* broadly elliptic to ovate-oblong, 4-13 x 1-4 (-6) mm [length to width ratio (1.5-) 2-3.5 (-4), distance of maximum width from base to total lamina length (0.14-) 0.2-0.4 (-0.6)]; base obtuse to sub-attenuate; hairs similar to those of branches, ± confined to upper surface, up to 30 (-80) hairs/ mm². *Pedicel* (1.5-) 2.5-5 (-13) mm long, usually sparsely hairy or glabrous; hairs similar to those of branches. *Calyx* (6-) 8-12 mm long, usually maroon, sometimes green; outer surface glabrous or sparsely to moderately hairy, up to 15 (-22) hairs/ mm²; hairs similar to those of branches, sparsely to densely glandular on outer surface; *tube* 4-6 (-7) mm long; lobes 3-4.5 (-5) mm long, 5-6 mm wide at base. *Corolla* red, often with yellow tinge distally, or metallic blue-green, occasionally yellow; *tube* 12-17 mm long. Fig. 56.

Typification

F. v. Mueller applied a broad concept to his 'consolidated' species, *P. coccinea.* His 'consolidated' species concept applied when he reduced a number of taxa to one species. Rather than use one of the existing names, he believed that the person who affected the reductions should 'choose a collective designation for the consolidated species' (von Mueller 1882, pp. vii. & viii). At various stages he included *P. aspalathoides*, *P. serpyllifolia*, *P. microphylla* and *P. caleyi* (Mueller 1855, 1868 & 1875). However, the majority of the annotated herbarium specimens are *P. serpyllifolia.* Contrary to this, most other authors appear to have applied a concept which is much closer to that of *P. microphylla.*

Of the material that I have examined, *Anon. s.n., s. dat.*, 'Prope m. Dutton. Fruticul. humil. diffus.' (MEL 43386) most completely fits the protologue. It is not known if Mueller would have regarded Mount Dutton as 'Spencer's Gulf' (as stated in the protologue). However, it is possible that he may have because he did not visit Eyre Peninsula (Churchill, *et al.* 1978) and so, may not have been aware of the exact locality of Mount Dutton. The brief description on the label (refer above) corresponds with the protologue, where Mueller describes this taxon as 'A low diffuse bush'. The only other specimen which is almost certainly a syntype of *P. coccinea* is *Anon. s.n., s. dat.*, 'Near Spencers Gulf' (MEL 43876).

Distribution

South Australia—[Yorke Peninsula] Southern Yorke Peninsula (Innes);—Western Pastoral: ?Gawler Ranges (*Sullivan s.n.*, MEL 43875);—[Eyre Peninsula] Central Mallee & Dunes (Kyancutta, Cleve, Hambidge, Tooligie, Blue Range, Hincks), West Coast (Drummond, Polda, Mt Cooper, Inkster, Streaky Bay), Southern Highlands & Plains (Marble Range, Yalunda, Peake Bay, Lincoln); Western Australia—(Eremaean: Coolgardie, see p. 296).

Ecology

Occurs on calcarenite ridges and in sandy soils? to sandy loam soils of undulating calcreted plains in Mallee communities. At Innes National Park (Yorke Peninsula) it occurs on the limestone cliffs in shallow skeletal calcareous sands, whereas at Mount Greenly (Eyre Peninsula) it is associated with coastal shrubbery in loamy soils amongst granitic rocks.

Notes

At Mount Greenly (refer Fig. 31) and some populations at Port Lincoln (e.g. Kirton Point), there is a long pedicellate form of this subspecies [pedicel (6-) 9-15 mm long; calyx 6-9 mm long]. Elsewhere, the pedicel is usually up to 6 mm long. At Innes National Park (Yorke Peninsula) a few specimens have long pedicels (pedicel 3-10 mm long; calyx 7-12 mm long). However, when the calyx is at least 9 mm long (in the latter population), the pedicel is usually less than 6 mm long. The taxonomic significance of this form is not known, but it does not appear to warrant formal taxonomic status. It is of interest to note that it appears to be restricted to quartzites and granitic gneisses rather than calcarenites (refer

Johns 1961). Specimens referable to this long pedicellate form are:

SOUTH AUSTRALIA.—[Eyre Peninsula] Central Mallee Plains & Dunes (Lincoln): *Alcock 807*, 23.x.1965, Proper Bay Road (AD); *Black s.n., s. dat.*, Port Lincoln (AD 96909025); *Browne s.n., s. dat.*, Port Lincoln (MEL 43407); *Cleland s.n.*, 17.xii.1941, Proper Bay (AD 966031652); *Dixon s.n.*, -.x.1883, Port Lincoln (AD 96928848); *Wilson 410*, 12.x.1958, Kirton Point (AD, UC); *Wilson 411*, 12.x.1958, Kirton Point (AD, M, SYD, UC); *Specht 2706*, 10.xi.1960, Flora & Fauna Reserve, 15 km SSE of Port Lincoln (AD); (Drummond): *Conn 684*, 20.ix.1979, Mt Greenly (AD); *Williams 2103*, 18.iv.1965, Mt Greenly (AD).

The smaller leafed individuals are often difficult to distinguish from the larger leafed specimens of ssp. *microphylla* in the Arno Bay, Hincks National Park, Kimba, and Bascombe Well regions of Eyre Peninsula (South Australia). However, the lamina of the former subspecies are usually not reflexed and their pedicels are usually longer than those of ssp. *microphylla*.

One collection from Western Australia (*Newbey 7135*) appears to be intermediate between this subspecies and ssp. *microphylla*. Typical of ssp. *serypyllifolia* it has unclustered leaves, more or less flat lamina, and petioles up to about 1 mm long. However, the relatively small leaves and short pedicel (up to about 2 mm long) are more typical of ssp. *microphylla*.

Selected specimens examined (c. 95 collections)

SOUTH AUSTRALIA.—[Yorke Peninsula] Southern Yorke Peninsula (Innes): *Alcock 4539*, 6.x.1974, southern end of eastern boundary, Innes National Park (AD); *Conn 1106*, 11.x.1981, Ethel Bay, Innes National Park (AD).—[Eyre Peninsula] Central Mallee Plains & Dunes (Kyancutta): *Ising s.n.*, 9.ix.1938, Wudinna (AD 97650196): (Cleve): *Alcock 1005*, 7.xii.1966, Cleve Parklands (AD); (Hambidge): *Barker 3639*, 28.ix.1978, opposite turnoff to Red Bank, near Arno Bay (AD); *Wheeler 561*, 3.x.1967, c. 7 km SW of Bascombe Well Homestead (AD); (Tooligie): *Cleland s.n.*, 9.xi.1960, Tooligie Hill (AD); (Blue Range): *Alcock 2202*, 7.x.1968, c. 1.6 km N of Oak Amphitheatre, Blue Range (AD); (Hincks): *Symon 6426*, 11.x.1968, c. 3 miles N of Butler Gate on southern boundary of Hincks National Park (ADW); (Drummond): *Wilhelmi s.n.*, -.i.1855, Lake Hamilton (HBG, MEL 41900, W); (Polda): *Eichler 19373*, 9.x.1967, Mt Wedge (AD); (Mt Cooper): *B. Copley 4801*, 10.ix.1975, Mt Cooper (AD); (Inkster): *Canning 23603*, 30.viii.1968, 15 miles from Poochera (AD); (Streaky Bay): *Donner 2484*, 13.x.1967, c. 40 km S of Streaky Bay (AD); (Marble Range): *E. Jackson 3656*, 1.x.1979, slopes of South Block (AD); (Yalunda): *M. Clarke s.n.*, 5.x.1965, Hundred of Koppio (AD 966042262); (Lincoln): *Richards s.n.*, -.x.1882, Port Lincoln road (MEL 43874).

WESTERN AUSTRALIA:—Eremaean: Coolgardie: *Newbey 7135*, 16.viii.1980, Fraser Range, c. 75 km SSW of Zanthus (MEL, PERTH).

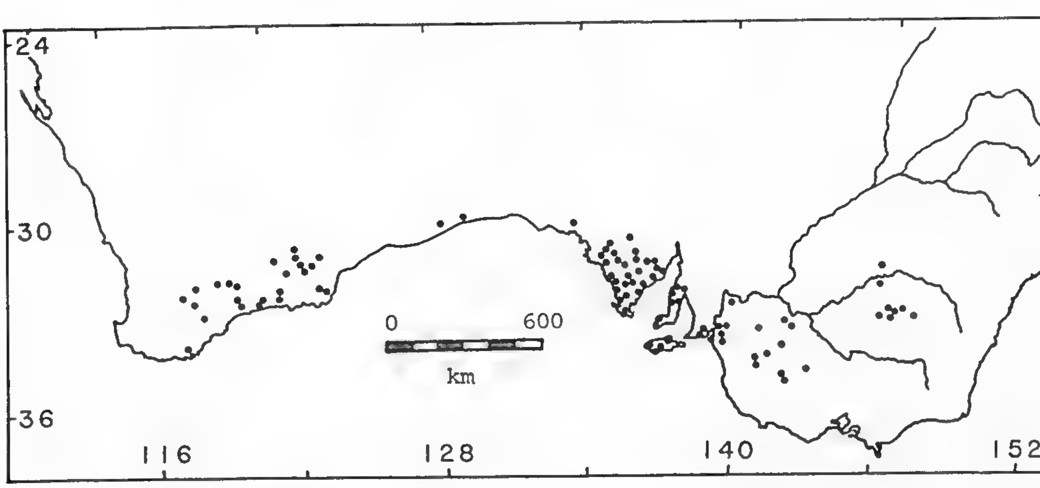


Fig. 57. Distribution map of *P. serpyllifolia*.

2.2 ssp. microphylla (R. Br.) Conn, *stat. nov.*

Cryphia microphylla R. Br., Prodr. (1810) 508; Sprengel, Linn. Syst. veg. ed. 16, 2 (1825) 704; Benth., Labiat. gen. spec. (1834) 448; G. Don, Gen. hist. 4 (1837) 798; Walpers, Rep. bot. syst. 3 (1844) 764; Benth., in DC., Prodr. 12 (1848) 559; Briq., in Engl. & Prantl, Nat. Pflanzenfam. 4, 3a (1895) 220 [as *P. microphylla* R. Br., *nom. illeg.*—latter homonym of *P. microphylla* A. Cunn. ex Benth. (1834)].

Type: *R. Brown* [*J. Bennett 2359*], *anno* 1802-5 [-.ii.1802], South Coast, Bay 10 [Pt Lincoln (Stearn 1960)], southern Eyre Peninsula, South Australia (BM *n.v.*; probable dupl. in E—upper left specimen, K *n.v.*). [refer Typification, below].

P. microphylla A. Cunn. ex Benth.,Labiat. gen. spec. (1834) 454; G. Don, Gen. hist. 4 (1837) 800; Walpers, Rep. bot. syst. 3 (1844) 767; Benth., in DC., Prodr. 12 (1848) 562; Fl. austral. 5 (1870) 106; F.M. Bailey, Queensl. fl. 4 (1901) 1204; Guilfoyle, Austral. pl. (1911) 305; F.M. Bailey, Compr. cat. Queensl. pl. (1913) 392; J.M. Black, Fl. S. Austral. ed. 1, 3 (1926) 492; Ewart, Fl. Victoria (1930) 982; C.A. Gardner, Enum. pl. austral. occid. (1931) 114; J.M. Black, Fl. S. Austral. ed. 2, 4 (1957) 738, 739; Hj. Eichler, Suppl. Black's fl. S. Austral. (1965) 269; Blackall & Grieve, W. Austral. wildfl. 3 (1965) 594; J.S. Beard, Descr. cat. W. Austral. pl. (*s. dat.* [Oct. 1965]) 94 [as *P. microphylla* (R. Br.) A. Cunn.]; Galbraith, Wildfl. SE. Austral. (1977) 325; Althofer, Cradle of Incense (1978) 74, 76, 82.

Lectotype (here chosen): [*A. Cunningham*], *s. dat.*, 'Eurylean [Euryalean] scrub' near Lachlan River, New South Wales (K—lower left specimen; probable isolecto. *A. Cunningham 225*, *anno* 1817, 'Near Lachlan River. Euryalian [Euryalean—near Yalgogrin North and Weethalle (McMinn 1970, p. 21)] scrub' (typed label), New South Wales (MEL 43382—centre right specimen). [refer Typification, below].

P. coccinea F. v. Muell., [Sec. gen. report veg. colony (Oct. 1854) 13, *nom. nud.*] Trans. Phil. Soc. Victoria 1 (1855) 48, *p.p.*, *lectotype excl.*; J. bot. Kew gard. misc. 8 (1856) 168, *p.p.*; Fragm. 6 (1868) 108, *p.p.*; *op. cit.* 9 (1875) 162, *p.p.*; Tepper, Trans. & Proc. Roy. Soc. S. Austral. 3 (1880) 31, 32, 43; Tate, Trans. & Proc. Roy. Soc. S. Austral. 3 (1880) 78; *op. cit.* 6 (1883) 145, 146, 165; F. v. Muell., Key Vict. pl. 2 (1885) 42; *op. cit.* 1 (1887) 385; Woolls, Pl. New S. Wales (1887) 385; Tate, *op. cit.* 12 (1899) 111; Handb. fl. extratrop. S. Austral. (1890) 151, 252; C. Moore, Handb. fl. New S. Wales (1893) 353; F. v. Muell. & Tate, Trans. & Proc. Roy. Soc. S. Austral. 16 (1896) 374; Dixon, Pl. New S. Wales (1906) 232; Pescott, Nat. fl. Victoria (*s. dat.* [1914]) 99. [refer Typification for ssp. *serpyllifolia* p. 295].

P. arenicola S. Moore, J. Bot. 59 (1921) 247; C.A. Gardner, Enum. pl. austral. occid. (1931) 114; Althofer, Cradle of Incense (1978) 74.

Holotype: *Sargent 858*, 22.x.1920, Gnowangerup, Western Australia (BM).

P. microphylla f. *aeruginosa* J.H. Willis, Vict. Natural. 73 (1957) 200; Ewart, Fl. Victoria (1930) 983 (as '*P. chlorantha* F. v. Muell.'); J.H. Willis, Handb. pl. Victoria 2 (1973) 587.

Holotype: *J.H. Willis s.n.*, 29.viii.1955, 'Rock Holes bore', NW Victoria, near South Australian border (MEL 43383). [refer Notes].

Branches moderately to densely hairy, (25-) 30-170 (-290) hairs/mm^2; hairs (0.09-) 0.12-0.46 (-0.52) mm long, recurved to reflexed, often appearing curled. *Leaves* usually clustered on short axes and arranged (unclustered) along long axes, sparsely to densely hairy; hairs similar to those of branches; leaves sessile or with *petiole* up to 0.3 (-0.5) mm long; *lamina* ovate to broadly elliptic, rarely narrowly ovate, (1-) 1.5-3 (-3.8) x (0.5-) 0.7-1.3 (-2.7) mm [length to width ratio (1-) 1.3-2.8 (-3.6), distance of maximum width from base to total lamina length (0.07-) 0.2-0.45 (-0.7)], often reflexed; base obtuse to rounded, sometimes ± truncate; abaxial surface usually glabrous, sometimes with an occasional hair; adaxial surface glabrous or sparsely to densely hairy, (0-) 7-60 (-113) hairs/mm^2; hairs similar to those of branches. *Pedicel* (0.8-) 1-3.5 (-4.8) mm long, sparsely to densely hairy; hairs similar to those of branches. *Calyx* (4.3-) 5-7.5 (-9.5) mm long, maroon or green; outer surface sparsely to densely hairy, rarely glabrous, (0-) 17-40 (-122) hairs/mm^2; hairs similar to those of branches; *tube* 3-5 mm long; *lobes* 1.5-2.2 mm long, c. 4 mm wide at base. *Corolla* bright pink to mid-red, often white basally, and/or with yellow tinge distally, or light metallic blue-green; *tube* 9-14 mm long. Fig. 58.

Typification

Brown (1810) does not cite any specimens for *Cryphia microphylla* in the protologue. As for *C. serpyllifolia* (refer to Typification notes for ssp. *serpyllifolia*), the locality is imprecisely cited as '(M)' [South Coast]. The only source of additional information is Brown's original collection (as held at BM) because he does not mention this taxon in his manuscripts (microfilm copy held at AD).

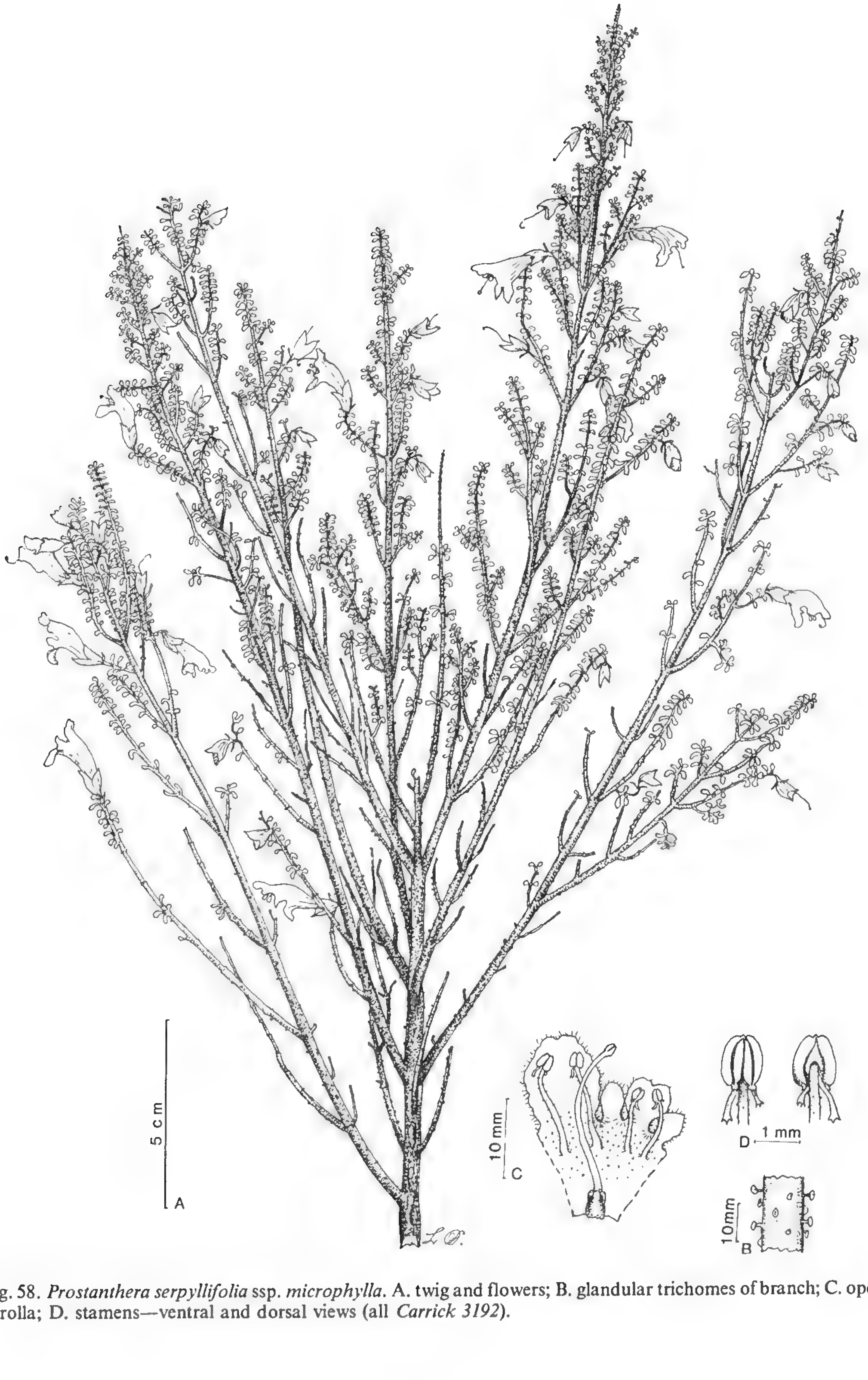


Fig. 58. *Prostanthera serpyllifolia* ssp. *microphylla*. A. twig and flowers; B. glandular trichomes of branch; C. open corolla; D. stamens—ventral and dorsal views (all *Carrick 3192*).

For the same reasons as given under ssp. *serpyllifolia*, I have delayed the choosing of a lectotype until I have examined Brown's collections in the British Museum. J. Carrick (*in adnot.*) indicates that one collection of Brown's, held at the British Museum (which I have not examined): 'Brown 2359. Cryphia microphylla, Bay IX South Coast'—seems likely to be part of the original collection.

Since J.J. Bennett distributed duplicates of Brown's collections to the Royal Botanic Gardens, Kew, and to the Royal Botanic Garden, Edinburgh (and other herbaria) (Stearn 1960), the upper left specimen on a sheet at Edinburgh (E): 'R. brown, Iter Australiense, 1802-5 Presented by direction of J.J. Bennett, 1876. No. Prostanthera microphylla? Genus inter Prostantheram Scutellariam. South Coast Bays 9 & 10', can probably be regarded as a syntype, and hence, may be chosen as an isolectotype.

A. Cunningham 225 (MEL 43382) is morphologically similar to *Anonymous* [*A. Cunningham*] (K). Furthermore, the locality information given in the protologue (Bentham 1834) and on the labels of the above two collections are similar. Therefore, the centre right specimen of *A. Cunningham 225* (MEL 43382) is here regarded as a probable isolectotype of *P. microphylla* A. Cunn. ex Benth.

The MEL material of *A. Cunningham 225* is a mixed collection which has subsequently been mounted on separate sheets. MEL 43382 contains four specimens of *P. serpyllifolia* ssp. *microphylla*, MEL 61361 has one specimen of *P. aspalathoides*, and MEL 61362 has one specimen of an unidentified species of *Prostanthera* section *Prostanthera* [possibly *P. scutellarioides* (R. Br.) Briq.].

Distribution

New South Wales—Central Western Slopes, South Western Plains; Victoria—western Northern Plains, Mallee; South Australia—Murray Mallee, Mt Lofty Block (incl. Kangaroo Island), Yorke and Eyre Peninsulas; Western Australia—Eremaean: south-eastern Eucla, southern Coolgardie; South-West: Eyre, Roe, south-eastern Darling, southern Avon.

Ecology

Refer species. At Cape Cassini (Kangaroo Island), it occurs on limestone cliffs in shallow skeletal soils. Between Kimba and Whyalla it occurs in *Triodia* dominated grass-lands (*Phillips 160*).

Notes

Most authors have applied a much narrower concept to *P. coccinea* than did Mueller. Although the exact concept used is not always clear, it seems that most authors regarded *P. coccinea* as very closely related to *P. microphylla.*

This subspecies is characterized by the small, usually ovate leaves which are recurved to reflexed. The calyx is consistently densely hairy in all Victorian populations and sparsely to densely hairy in New South Wales populations. In South Australia, the calyx is sparsely to densely hairy in those populations east of Murray Bridge (with few exceptions), Kangaroo Island (except at Cape Cassini), and central and northern Yorke Peninsula. Populations on northern Eyre Peninsula mostly have a hairy calyx, whereas those further South are more variable, such that the calyx is frequently glabrous. The populations in Western Australia are similar to those of Eyre Peninsula.

P. microphylla f. *aeruginosa* is reduced to synonymy because it is merely a colour form in a taxon which is extremely variable with respect to corolla colour.

Common names: Small-leaved mint-bush (Bailey 1883); Small-leaf mint-bush (Blackall & Grieve 1974, Ewart 1930, Willis 1973); Small mintbush (Cunningham *et al.* 1982).

Selected specimens examined (c. 230 collections)

NEW SOUTH WALES.—Central Western Slopes: *Kaspiew 1342*, 24.xii.-, Cowra (F).—South Western Plains: *Whaite 2726*, 21.ix.1963, 31 miles N of Hillston on Cobar road (NSW).

VICTORIA.—Mallee: *Beauglehole 1064*, -.x.1948, Hattah Lakes National Park (AD).—Northern Plains: *Dalton s.n.*, 27.ix.1911, Dimboola District (LE); *Walter s.n.*, 29.i.1889, West Wimmera (GH, MO, P).

SOUTH AUSTRALIA.—Murray Mallee: Upper Murray Lands (Pata): *Specht 2360*, 14.x.1960, c. 80 km SSE of Renmark (AD).—Northern Calcarenite Ridges & Plains (Coonalpyn): *Beauglehole 17538*, 26.x.1967, c. 8 km W of Coonalpyn (AD); (Catnana): *Grivell s.n.*, 1.x.1968, Yumali (AD 97050460) (Coorangie): *Sharrad 241*, 4.x.1959, Malinong (AD).—South East Mallee Heathlands (Billiatt): *van der Sommen s.n.*, -.xi.1974, c. 16 km S of Paruna (AD 97449148); (The Big Desert): *Symon 8660*, 22.x.1973, Scorpion Springs Conservation Park (AD, ADW); (Moorlands): *Williams 1037*, 2.x.1960. c. 50 km SSE of Murray Bridge (AD); (Karoonda): *A. Burbidge s.n.*, 26.ix.1971, c. 25 km E of Murray Bridge (AD 97142004).—Mt Lofty Block: Peninsula Uplands (Sandergrove): *Ising s.n.*, -.vi.1925, Kinchina (AD 97249327).—Kangaroo Island (Stokes Bay): *Conn 1073*, 13.xi.1980, Cape Cassini (AD); (Parndana): *Eichler 15172*, 3.xi.1958, Cape Borda (AD); (Gantheaume): *B. & H. Conn 1089-1092*, 14.xi.1980, Kelly Hill Cave (AD).—Yorke Peninsula: Gulf Plains (Barung): *Donner 1871*, 12.x.1966, c. 11 km S of Bute (AD); (Boor Plains): *Phillips s.n.* (*CBG 23839*), 2.x.1965, 16 miles from Kadina towards Port Wakefield (AD); (Weetulta): *B. Copley 4091*, 15.ix.1973, c. 6 km SE of Moonta (AD).—Southern Yorke Peninsula (Urania): *Gill 152*, 29.ix.1890, near Maitland (MEL); (Corny): *Wrigley WA/68 7745*, 24.xi.1968, 12 miles from Corny Point (AD).—Western Pastoral: Gawler Uplands (Gawler): *Lay 686*, 29.ix.1972, c. 5 km S of Yarna Homestead (AD).—[Eyre Peninsula] Northern Myall Plains (Buckleboo): *Rohrlach 625*, 7.x.1959, 40 km WNW of Kimba (AD); (Thurlga): *Warnes s.n.*, 1.ix.1968, Thurlga Station (AD 96850109): (Middleback Range): *Phillips 160*, 29.viii.1968, 41 miles from Whyalla towards Kimba (CBG 23621).—Central Mallee Plains & Dunes (Ironstone Hill): *Eichler 19193*, 28.viii.1967, 11 km E of Refuge Rockhole (AD); (Kimba): *Caulfield 236*, 29.ix.1955, Kimba (AD); (Pinkawillinie): *Orchard 2138*, 15.viii.1969, c. 56 km E of Kimba (AD, UC); (Kyancutta): *Chinnock 2790*, 4.x.1975, 29 km NW of Minnipa (AD); (Cleve): *Alcock 632*, 2.ix.1965, c. 17 km N of Arno Bay (AD); (Darke Peake): *Ising s.n.*, 30.viii.1935, Darke Peake (AD 97249342); (Hambidge): *Kraehenbuehl 2061*, 9.x.1966, Hambidge National Park (AD); (Tooligie): *Cleland s.n.*, 9.xi.1960, Tooligie Hill (AD 966071287); (Blue Range): *Wheeler 748*, 6.x.1968, slopes of Verran Hill (AD); (Hincks): *Symon 6192*, 8.x.1968, along North Diagonal road, Hincks National Park (ADW).—Southern Highlands & Plains (Butler): *Whibley 7426*, 2.x.1980, 11 km NNE of Ungarrd (AD): (Peake Bay): *Wilhelmi s.n., s. dat.*, Tumby Bay (MEL 43385); (Mt Gawler): *Whibley 1961*, 27.viii.1967, c. 8 km NE of Port Neill (AD); (Lincoln): *J. Veitch for Beauglehole 17574*, *anno* c. 1950, Port Lincoln (AD).—West Coast (Drummond): *J. Veitch s.n.*, 3.xi.1949, Mt Hope (AD 966051161); (Polda): *Ising s.n.*, 16.ix.1938, Venus Bay (AD 97650199).

WESTERN AUSTRALIA.—Eremaean: south-eastern Eucla: *George 8519*, 15.x.1966, 3.5 miles E of Eucla (PERTH).—southern Coolgardie: *Armitage 522*, 4.x.1973, 68 miles S of Norseman (PERTH).—South West: southern Avon: *Gardner 1998*, 3.ix.1923, Dumbleyung (PERTH); Roe: *Royce 8882*, 23.x.1969, 3 miles N of Grass Patch (PERTH); south-eastern Darling: *Cronin s.n.*, *anno* 1892, near King George's Sound (MEL 43868); Eyre: *Royce 9302*, 24.x.1970, Coppermine Creek, Fitzgerald River National Park (PERTH).

3. **Prostanthera patens** Conn, *sp. nov.*

Species nova Sectionis Klanderiae. *Frutices* parvi. *Rami* et ramuli spiniformes, moderate tomentosi, glandiferi. *Folia* dense tomentosa; *petiolus* usque ad 0.3 (-0.5) mm. longus; *lamina* ovata usque late elliptica 1.4-2.3 mm longa, 0.8-1.5 mm. lata, basi obtusa usque rotundata, margine integro, recurvo, apice obtuso usque rotundato. *Pedicellus* florum 1.5-3.2 mm. longus, dense tomentosus, *prophyllis* circa 1 mm. e basi calycis affixis, mox caducis. *Calyx* (5-) 6-7.7 mm. longus, extra et intra plus minus dense tomentosus, pilis 0.2-0.3 mm. longis; *tubus* 4-4.5 mm. longus; *lobi* plus minusve deltoidei, 2.4-3.5 (-4) mm. longi, circa 3.5 (-5.5) mm. lati, margine integro, apice obtuso usque late rotundato. *Corolla* 22-27 mm. longa, aurantiaca usque rubra, extra moderate usque dense tomentosa, intra in partibus distalibus sparsim tomentosa; *tubus* 11-17 mm. longus; *lobus abaxiali-medianus* late oblongus, 4-5.5 mm. longus, recurvus, margine integro, apice obtuso, saepe emarginato, sinu circa 0.2 mm. longo, *lateralibus* angusto-deltoideis usque plus minusve oblongis, 3-4 mm. longis, recurvis, margine integro, apice obtuso, saepe emarginato, sinu circa 0.2 mm. longo, *adaxiali-mediano* late obovato, 5-9 mm. longo, margine integro, apice rotundato, emarginato, sinu 0.2-0.6 mm. longo. *Stamina* circa 8 mm. e basi corollae affixa; filamenta 6-8 mm. longa; antherae circa 1.5 mm. longae, appendice 1-1.7 mm. longa. *Pistillum* 22-27 mm. longum; ovarium circa 0.6 mm. longum; stylus 20-25 mm. longus; lobis stigmatis 0.4-0.5 mm. longis. *Fructis* non visis.

Holotypus: *Ashby 5209*, 24.viii.1975, east of Pindar, Avon botanical district, Western Australia (AD; iso MEL).

Small shrub, height unknown. *Branches* ± terete, stiff, spine-like, moderately hairy, particularly at nodes, (34-) 40 hairs/mm^2; hairs 0.1-0.2 mm long, ± appressed [base of hair

Fig. 59. *Prostanthera patens*.—A. twig and flowers; B. open corolla; C. stamens—ventral and dorsal views (all *Alpin 2551*).

to first bend c. 0.03 (-0.05) mm; greatest distance hair from branch up to 0.05 mm], translucent to white; sparsely to moderately glandular; glands globular, raised. Leaf bearing branches short to long. *Leaves* clustered or arranged along branches, densely hairy, 128-220 hairs/mm^2, sparsely to moderately glandular, up to 20 glands/mm^2; glands slightly raised; *petiole* ± terete, up to 0.3 (-0.5) mm long; *lamina* ovate to broadly elliptic, often appearing ± oblong because margin recurved, 1.4-2.3 x 0.8-1.5 mm [length to width ratio (0.9-) 1.5-2.8, distance of maximum width from base to total lamina length 0.19-0.43]; base obtuse to rounded; margin entire, recurved; apex obtuse to rounded; venation indistinct; midrib sometimes slightly raised on abaxial surface. *Pedicel* 1.5-3.2 mm long, ± terete, usually maroon, densely hairy; hairs 0.1-0.2 mm long, appressed to suberect, white; *prophylls* inserted approximately halfway along pedicel [ratio of anthopodium length to a_1 axis length 0.8-1.3], not overlapping with base of calyx, soon deciduous, narrow-oblong, 0.8-1.3 x 0.3-0.5 mm [length to width ratio 1.6-4], hairy; margin entire; apex obtuse. *Calyx* (5-) 6-7.7 mm long, green to maroon; outer surface densely hairy, 128-215 hairs/mm^2; hairs 0.2-0.3 mm long, ± appressed, white; inner surface moderately to densely hairy, 56-185 hairs/mm^2; *tube* 4-4.5 mm long; *lobes* ± triangular, 2.4-3.5 (-4) mm long, c 3.5 (-5.5) mm wide at base; margin entire; apex obtuse to broadly rounded. *Corolla* 22-27 mm long, orange to pale red basally, red distally; outer surface moderately to densely hairy; hairs c. 0.2 mm long, with a few scattered glands to moderately glandular; inner surface glabrous at base, sparsely hairy above, especially on lobes; *tube* 11-17 mm long; *abaxial median lobe* broadly oblong, 4-5.5 mm long, recurved; margin entire; apex obtuse, often emarginate; sinus c. 0.2 mm long; *lateral lobes* narrow-triangular to oblong, 3-4 mm long, recurved; margin entire; apex obtuse; *adaxial median lobe-pair* broadly obovate, 5-9 mm long; margin entire; apex rounded, emarginate; sinus 0.2-0.6 mm long. *Stamens* inserted c. 8 mm above base of corolla; filaments 6-8 mm long, with scattered glandular trichomes; anthers 1.5 mm long; base of lobes with acumen c. 0.2 mm long; connective basally extended to form an appendage 1-1.7 mm long. *Pistil* 22-27 mm long; ovary c. 0.6 mm long, diameter at base 1-1.2 mm, lobes 0.3 mm long; style 20-25 mm long, sometimes with a faint median groove; stigma lobes 0.4-0.5 mm long. *Fruits* not known. Figs 59 & 68.

Distribution

Western Australia (Eremaean: Austin; South-West: Avon).

Conservation status: The conservation status of this species is not known—Risk code = 3K (?V).

Ecology

Little known of associations and geology. "Growing with *Wrixonia*" (*Ashby 5220*), "Not in heath country" (*Ashby 5209*), "ironstone scree on slope of B.I.F. ridge" (*Blockley 488*).

Notes

This new species was included in the *P. laricoides* complex as a result of various numerical analyses (in particular, refer Figs 6 & 8). However, numerical analysis (pp. 243-245) and a study of morphological variation (pp. 263-268) in this complex indicate that *P. patens* can be distinguished by many characters from the other species of the complex. The distinctness of *P. patens* is clearly illustrated in Figs 16-19. Therefore, the inclusion of this species in this complex is inappropriate. Its closest affinites appear to be with *P. serpyllifolia*. Both species have small leaves and long anther appendages. The spine-like branches of *P. patens* give this species a distinctive habit and the hairy inner surface of the calyx readily distinguish it from *P. serpyllifolia*.

Specimens examined

WESTERN AUSTRALIA.—Eremaean: Austin: *Alpin 2551*, 26.viii.1963, 25 miles N of Paynes Find (PERTH); *Beard 2653*, 10.viii.1965, N of Payne's Find (KP).—South-West; Avon: *Ashby 5209*, 24.viii.1975, E of Pindar (AD, MEL): *Ashby 5220*, 31.viii.1975, between Perenjori and the Inland Highway (Paynes Find Road) (AD, MEL): *Blockley 488*, 27.viii.1967, S of Paynes Find on Great Northern Highway (KP); *Burns 1037/2*, -.x.1966, Morawa (PERTH); *Lullfitz 2427*, 9.ix.1963, 22 miles from Sandstone towards Mt Magnet (KP).—No locality: *Steenbohm s.n.*, -.x.1961, *s. loc.* (PERTH).

4. **Prostanthera calycina** F. v. Muell. ex Benth., Fl. austral. 5 (1870) 107; Tate, Trans. & Proc. Roy. Soc. S. Austral. 3 (1880) 78; *op. cit.* 12 (1889) 111; Handb. fl. extratrop. S. Austral. (1890) 151, 252; Briq., in Engl. & Prantl, Nat. Pflanzenfam. 4, 3a (1895) 220 (as '*P. calicina*'); J.M. Black, Fl. S. Austral. ed. 1, 3 (1926) 492; *op. cit.* ed. 2, 4 (1957) 738; Galbraith, Wildfl. SE. Austral. (1977) 325; Althofer, Cradle of Incense (1978) 78, 80, 82.

Lectotype (here chosen): *Warburton s.n., s. dat.*, Venus Bay, Eyre Peninsula, South Australia (MEL 41899). Other syntypes: *Wilhelmi s.n., s. dat.*, Coast ranges to the west of Lake Hamilton, Port Lincoln (MEL 41900); *Wilhelmi s.n., s. dat.*, Port Lincoln (MEL 41901). [refer Typification].

Small ± prostrate shrubs, c. 0.5 m high. *Branches* ± terete, often slightly flattened distally, often with faint grooving on internodes (from one leaf axis to the next node alternatively) moderately to densely hairy, 54-117 hairs/mm^2, hairs (0.1-) 0.3-0.4 (-0.5) mm long, stiff and straight (for most of length), appressed [base of hair to first bend usually less than 0.05 mm long; greatest distance hair from stem is less than 0.8 (-1) mm]; hair apex directed towards distal part of branches; sparsely glandular, up to 18 glands/mm^2. *Leaves* arranged along the axis and branches, not clustered on short shoots, usually sparsely, rarely densely hairy, occasionally glabrous; hairs similar to those of branches; *petiole* 0.8-1.4 mm long, ± flattened, densely hairy, similar to those of branches; *lamina* elliptic to ovate-oblong, 4-14 x 3-5 mm [length to width ratio 1.4-3.8, ratio of distance of maximum width from base to total lamina length 0.4-0.6]; base obtuse to subattenuate; margin entire; apex obtuse to rounded; hairs ± restricted to margin and midrib of abaxial surface, ± confined to margin and apex of adaxial surface, up to 30 hairs/mm^2, similar to those of branches; venation indistinct or not visible. *Pedicel* 2.5-4.5 (-7) mm long, often maroon, densely hairy; hairs similar to those of branches; *prophylls* inserted at base of calyx, hence overlapping basal part of calyx, narrow-obovate to ± oblong, 1.5-4 x c. 0.5 mm [length to width ratio (3-) 5-7.5], slightly concave, densely hairy, at least near base, sparsely hairy at apex; hairs sometimes restricted to margin; apex obtuse. *Calyx* 8-14 mm long, usually maroon, sometimes green; outer surface sparsely to moderately hairy, particularly along veins, up to 15 hairs/mm^2; hairs similar to those of branches, moderately glandular on outer surface, 9-17 glands/mm^2; inner surface glabrous; *tube* 6-8 mm long; *lobes* ± triangular, 4-6 mm long, 5-7 mm wide at base; apex obtuse to broadly rounded. *Corolla* 17.5-22 mm long, red; outer surface distally sparsely to moderately hairy; hairs c. 0.1 mm long; inner surface glabrous; *tube* 13-15 mm long; *abaxial median lobe* ± obovate, c. 4 mm long, c. 3 mm wide, ± recurved to reflexed; margin entire; apex rounded; *lateral lobes* narrow, ± triangular to ovate, c. 3 mm long, ± recurved to reflexed; margin entire; *adaxial median lobe-pair* broadly triangular, c. 5 mm long; margin entire; apex obtuse, sometimes slightly emarginate; sinus up to 0.2 mm long. *Stamens* inserted c. 8.5 mm above base of corolla; filaments c. 5.5 mm long, with a few scattered minute glandular trichomes; anthers 1.5-2 mm long; base of lobes with minute acumen c. 0.06 mm long; connective extended to form a short basal appendage (0.1-) 0.4-0.8 mm long. *Pistil* 12-15 mm long; ovary 0.5-0.7 mm long, diameter c. 0.6-1 mm at base, lobes small, c. 0.1 mm long; style 11-14 mm long, sometimes with faint median groove; stigma lobes up to 0.3 mm long. *Fruit* unknown. Fig. 60.

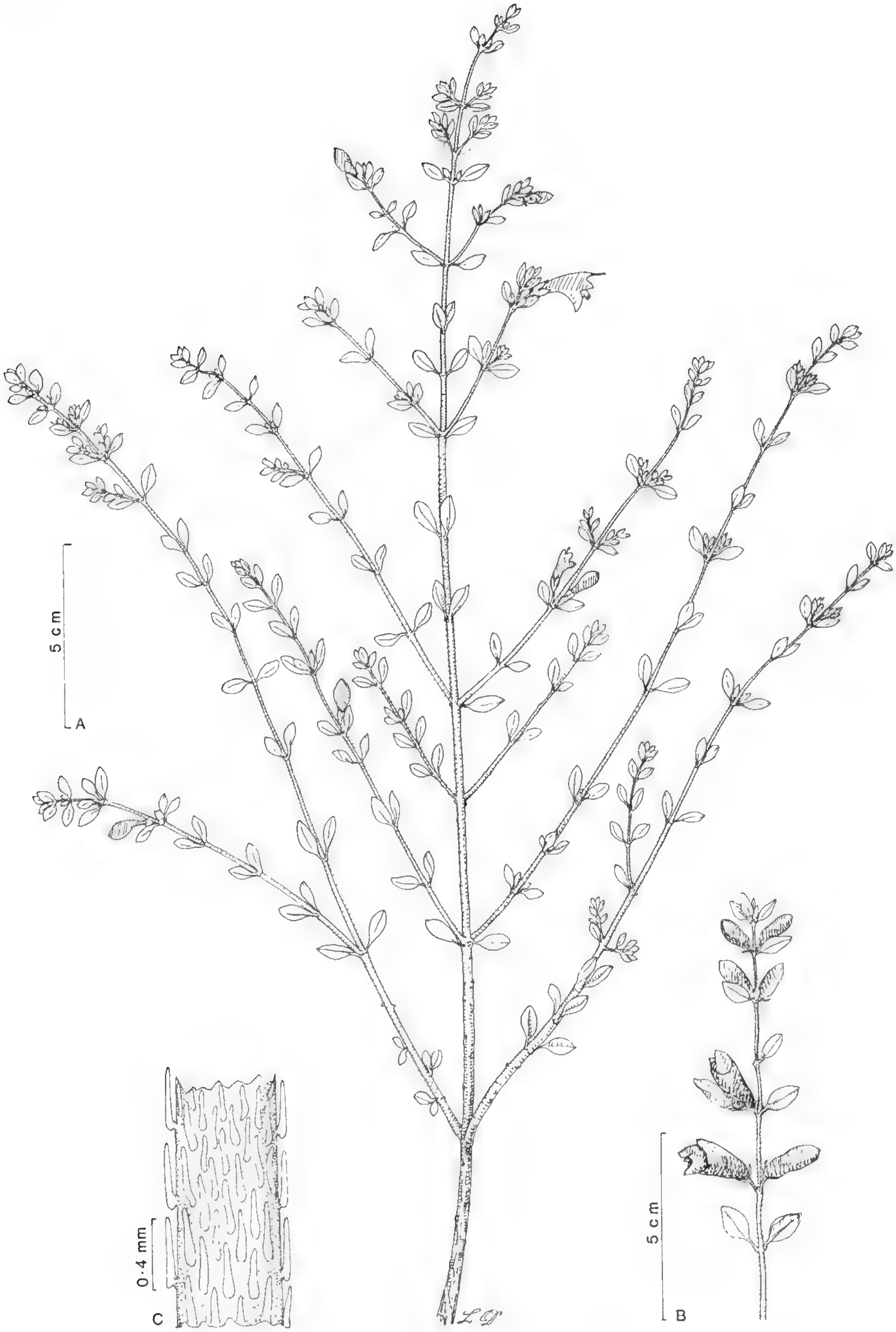


Fig. 60. *Prostanthera calycina*.—A. twig and flowers (*Weber 6210*); B. twig and flowers; C. hairs on branch (all *Warburton s.n.*).

Typification

Bentham (1870) cited two collections in the protologue of *P. calycina* (*viz. Wilhelmi*, Port Lincoln; and *Warburton*, Venus Bay). The specimen collected by *Warburton* (as held at MEL) has one mature (open) corolla, whereas the *Wilhelmi* collections (two sheets at MEL) have old calyces and a few young buds. The *Warburton* collection and *Wilhelmi* (MEL 41901) specimen were examined by Bentham. Since Bentham described the corolla in the protologue, the *Warburton* collection (which has mature corollas) is here chosen as the lectotype.

Distribution

South Australia—western coastal and southern Eyre Peninsula: West Coast (Polda, Drummond, Edillie, Lincoln), Central Mallee and Dunes (Ceduna).

Conservation status

This species is possibly at risk (Risk Code = 2K, [Conn, in] Leigh *et al.* 1981, pp. 49 & 86).

Ecology

Occurs on calcarenite ridges and in sandy loams of undulating calcreted plains in Mallee communities. Commonly associated with *Eucalyptus incrassata*, *E. oleosa*, *E. socialis*, and frequently with *Melaleuca*, *Pittosporum*, *Santalum acuminatum*, and various shrubs (such as *Grevillea*, *Hakea* and *Spyridium*).

Notes

This species has a very distinctive hair type which is not found in any other taxon of this section (sect. *Klanderia*). The hairs are appressed, straight for most of their length, stiff, and directed towards the distal part of the organ on which they occur. It has its closest affinities with *P. serpyllifolia*. The relatively large calyx is a useful secondary feature which distinguishes this species from *P. serpyllifolia* ssp. *microphylla*. For further details on the relationship of this species with *P. serpyllifolia*, refer 'Numerical analysis of the *Prostanthera calycina—P. microphylla—P. serpyllifolia* complex' and 'Morphological variation in the *Prostanthera calycina—P. microphylla—P. serpyllifolia* complex'.

Selected specimens examined (15 collections)

SOUTH AUSTRALIA.—[Eyre Peninsula] Central Mallee & Dunes (Ceduna): *Richards s.n.*, *anno* 1883, Fowler's Bay (MEL 41898).—West Coast (Polda): *Richards s.n.*, *anno* 1887, between Port Lincoln & Streaky Bay (MEL 43873); (Drummond): *Wilhelmi s.n.*, -.i.1855, Lake Hamilton (HBG, MEL 41900, W); (Edillie): *Phillips 6653*, 27.viii.1964, 1 mile from Wanilla, towards North Shields (AD); (Lincoln): *Wilhelmi s.n.*, *s. dat.* [*anno* 1885], Port Lincoln (MEL 41901).

5. **Prostanthera aspalathoides** A. Cunn. ex Benth., Labiat. gen. spec. (1834) 453; G. Don, Gen. hist. 4 (1837-8) 799; D. Dietr., Syn. pl. 3 (1842) 427; Walpers, Rep. bot. syst. 3 (1844) 767; Benth. in DC., Prodr. 12 (1848) 562; Fl. austral. 5 (1870) 107; Briq., in Engl. & Prantl, Nat. Pflanzenfam. 4, 3a (1895) 220; J.M. Black, Fl. S. Austral. ed. 1, 3 (1926) 491; Ewart, Fl. Victoria (1930) 982; J.M. Black, Trans. & Proc. Roy. Soc. S. Austral. 55 (1931) 141; Fl. S. Austral. ed. 2, 4 (1957) 738, t. 1057; Hj. Eichler, Suppl. Black's fl. S. Austral. (1965) 269; Blombery, A guide to native Austral. pl. (1967) 309; Cochrane *et al.*, Flowers & pl. Victoria (1968) 53, fig. 128; Galbraith, Wildfl. SE. Austral. (1977) 325, pl. 27; Holliday & Watton, Austral. native shrubs (1978) 182 & 183, Althofer, Cradle of Incense (1978) 74, 75, 77, 79, 82 & 83.

Lectotype (here chosen): *A. Cunningham 224*, 24.v.1817, 'Dwarf shrub, Mr Oxley's first

expedition, down Lachlan River, on barren rugged hills' (K; probable isolecto: *A. Cunningham 224*, *anno* 1817, New South Wales, near Mount Aiton, BM, MEL 42918). [refer Typification].

P. coccinea [non F. v. Muell., Trans. Phil. Soc. Victoria 1 (1855) 48] F. v. Muell., Fragm. 6 (1868) 108, *p.p.* lectotype excl. [refer 'Typification' for *P. serpyllifolia* ssp. *serpyllifolia*, p. 295].

P. eriocalyx Gand., Bull. Soc. Bot. France, 65 (1918) 6.

Holotype: *Walter s.n.*, -x.1892, 'N. West Victoria' (LY; iso in NSW). [refer Tindale in McGillivray (1973, p. 352)].

P. patula Gand., *loc. cit.*

Holotype: *Sutton s.n.*, -.x.1905, 'Australia. Wimmera, Victoria' (LY; iso in NSW). [refer Tindale in McGillivray (1973), p. 352)].

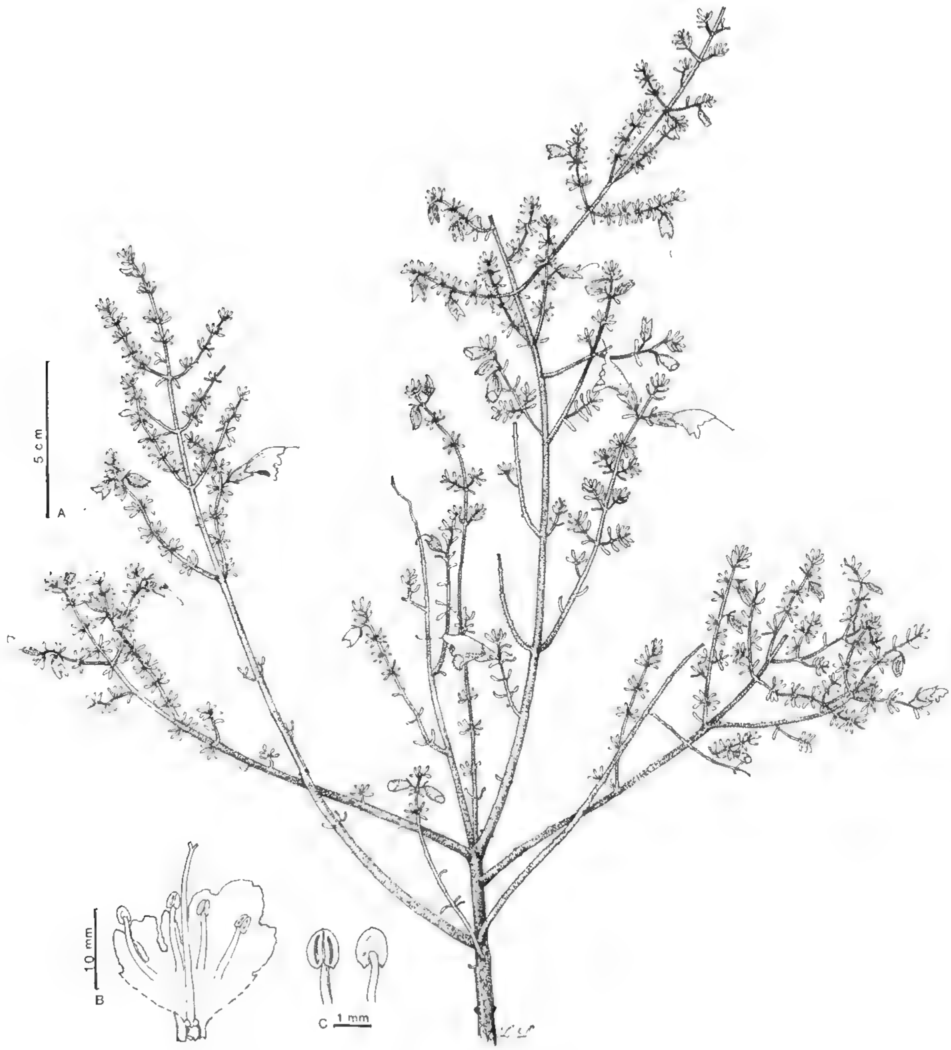


Fig. 61. *Prostanthera aspalathoides.*—A. twig and flowers; B. open corolla; C. stamens—ventral and dorsal views (all *Carrick 2944*).

Small shrub, 0.3-1 m high. *Branches* ± terete, densely hairy; hairs c. 0.1 mm long, glandular. Leaf bearing branches short to long, when short, leaves often densely clustered at nodes of axis, when long, branches 2-4 mm long, then leaves spread out along branches. *Leaves* glabrous or sparsely tomentose, 0-40 (-66) hairs/mm²; hairs (0.05) 0.1-0.3 mm long, glandular, 15-50 (-100) glands/mm²; *petiole* absent or if present, then less than 0.5 mm long; *lamina* terete to compressed-terete, oblong-linear, linear-elliptic to linear-obovate, (1.5-) 2-6 (-10) x 0.5-1 mm [length to width ratio 3-6 (-10), distance of maximum width from base to total lamina length 0.07-0.92]; base slightly attenuate; margin entire, recurved when lamina subterete; apex obtuse to rounded; venation not visible. *Pedicel* 2-3 mm long, tomentose to glabrous; *prophylls* inserted near distal end of pedicel, and so overlapping basal part of calyx, narrowly oblong, 2-3 mm long, concave; abaxial surface sparsely tomentose, especially near margin, adaxial surface frequently sparsely fimbriate; apex obtuse. *Calyx* 5-7 mm long; outer surface sparsely to densely hairy, rarely glabrous; inner surface glabrous; *tube* 3-4 mm long; *lobes* broadly lanceolate to ± triangular, 2-3 mm long, c. 3 mm wide at base; apex obtuse. *Corolla* 10-20 mm long, red, pink-red, orange, rarely yellow; outer surface distally hairy; inner surface usually with dark red spots on lower lips; *tube* 8-11 mm long; outer surface distally sparse to densely hairy; *lobes* sparsely hairy on outer surface; inner surface glabrous; *abaxial median lobe* obovate, slightly bilobed, 2-3 mm long, 2-4 mm wide at base; margin entire to irregular; apex obtuse to slightly bilobed; sinus up to 1 mm long; *lateral lobes* ovate to oblong-ovate, or ± triangular, 1.5-3 (-4) mm long, 1.5-2 (-3) mm wide at base; *adaxial median lobe-pair* ± ovate, often slightly 3-lobed, 5-8 mm long, 6-8 mm wide at base; apex obtuse, sometimes emarginate; sinus up to 0.5 mm long. *Stamens* inserted c. 10 mm above base of corolla; filaments 6-8 mm long, with broad-deltoid glandular trichomes; anthers 1.5-2 mm long, although appendage appearing absent, one side of connective usually extended to form a minute basal appendage up to 0.3 (-0.5) mm long, sometimes with broad-deltoid trichomes on appendage. *Pistil* 17-18 (-25) mm long; ovary 1-1.5 mm long, diameter c. 1 mm at base, lobe small, c. 0.3 mm long; style 15-20 (-23) mm long; stigma lobes up to 1 mm long. *Mericarps* 2-2.5 mm long, distally 0.5-1 mm extended beyond base of style. Figs 61-63.

Typification

Bentham (1834) cited '*A. Cunningham*' as the collector of the type of *P. aspalathoides*. There is close agreement between the brief description provided in the protologue and *Cunningham 224*. Furthermore,the herbarium label on the K sheet (p. 306) corresponds with the locality given in the protologue ('in collibus aridis sterilibus ad fluvium Lachlan'; Bentham 1834, p. 454). Therefore, *Cunningham 224* (K) is here chosen as the type for this species.

Distribution

Queensland (Maranoa—*R. Jordan s.n.*, -.viii.1953, St George), New South Wales (Central Western Slopes, South Western Plains, South Far Western Plains), Victoria (Mallee, Northern Plains) and South Australia (Murray Mallee, Mt Lofty Block—(incl. Kangaroo Island), Gulf Plains—[Yorke Peninsula], Northern Myall Plains and Central Mallee and Dunes—[Eyre Peninsula].

Conservation status: considered not at risk.

Ecology

Occurs in open Mallee communities (*Eucalyptus incrassata*, *E. socialis*) with open understorey commonly of *Melaleuca lanceolata*, *M. uncinata*, *Triodia* sp. and other heathland plants (*Barker 4133*; *Beauglehole 28862*, *29015*, *29555*), occasionally with *Callitris preissii* (*Conn 1040*; *Melville 1085*), frequently in roadside communities. It occurs on sandstones and shales (*Melville 1310*), amongst sandstone outcrops (*Beauglehole 29015*),

Fig. 62. *Prostanthera aspalathoides.*—A. twig and flowers; B. open corolla; C. stamens—ventral and dorsal views (all from cultivated material, Adelaide Botanic Gardens).

on red sandy loams (*Conn 1042*), overlying granite (*Brickhill s.n.*, 3.x.1979; *Conn 775*) or in shallow, calcareous soils (*Conn 1043*). Often in sandy soils with high 'buckshot' gravel content (*Conn 703*), less commonly occurring in soils with high clay content.

Note

There is considerable variation in the size of the leaves of *P. aspalathoides* (refer Figs 61A & 62A). For example, *Ising s.n.*, 9.ii.1937 (AD 966081719); *Kraehenbuehl 913* (AD); and *Wheeler 457* (AD, MEL) have very small leaves (2-2.5 x c. 0.7 mm) similar to *P. serpyllifolia* ssp. *microphylla*, whereas *Blaylock 1306* (A, AD) has very long leaves (11-20 x 0.6-1.2 mm). In the Waikerie and Billiatt National Park areas of South Australia, the leaves are slightly flattened narrow-elliptic, similar to *P. serpyllifolia* ssp. *serpyllifolia*. However, *P. aspalathoides* usually has the leaves crowded on short shoots, e.g. *Aitkens s.n.*, 24.x.1974 (AD 98108051, MEL), *Carrick 3306*, 3307 (AD, MEL), and *Whibley 3645* (AD, MEL), whereas those of *P. serpyllifolia* are arranged along the long axes.

This species is closely related to *P. florifera* (refer pp. 310-313). It differs from the latter by having a much shorter anther appendage (up to 0.5 mm long *cf.* 1-2.5 mm long for *P. florifera*) and usually smaller calyces (5-7 mm long *cf.* 7-12 mm long for *P. florifera*). Although the length of the anther appendage of *P. aspalathoides* is short, it is quite variable: appearing absent (e.g. Fig. 61C) or up to 0.3 (-0.5) mm long (e.g. Fig. 62C).

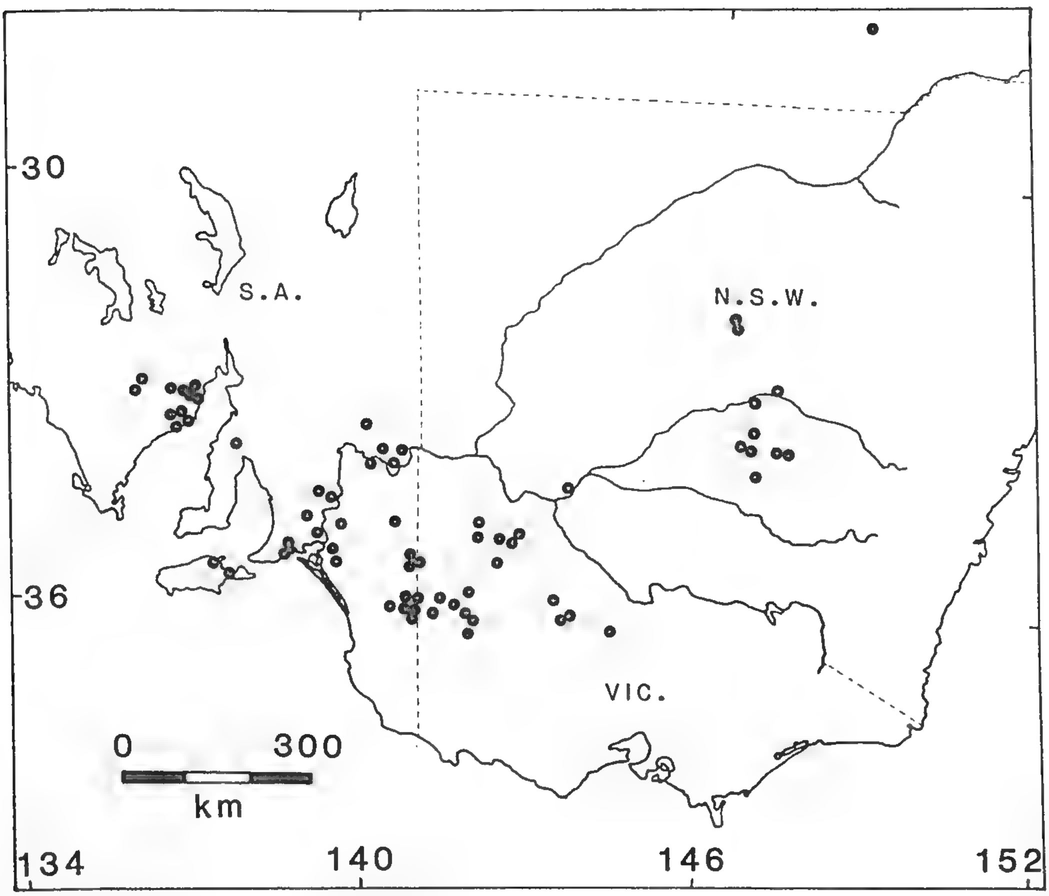


Fig. 63. Distribution map of *Prostanthera aspalathoides*.

Common name: Scarlet mint-bush (mintbush) (Blackall & Grieve 1974, Cunningham *et al.* 1982, Ewart 1930, Willis 1973).

Selected specimens examined (420 collections)

NEW SOUTH WALES.—Central Western Slopes: *Tindale s.n.*, -.x.1963, 5 miles from W. Wyalong (A, AD 96401023, NSW 63772).—South Western Plains: *Conn 760-768*, 22.viii.1980, 12-15 km E of Rankin Springs (AD, MEL).—South Far Western Plains: *Phillips CBG 23840*, 15.ix.1965, 9 miles from Balranald (AD 97001168).

VICTORIA.—Mallee: *Beauglehole 28862*, 2.x.1968, Dattuck track, Wyperfeld National Park (AD).—Northern Plains: *B. & H. Conn 703*, 31.x.1979, 22 km NNE of Bendigo (AD); *Morris 1527*, 14.x.1926, Wederburn (NSW).

SOUTH AUSTRALIA.—Murray Mallee: Upper Murray Lands (Parcoola): *Munir 5059, 5060*, 26.ix.1971, c. 16 km N of Overland Corner (AD); (Renmark): *Reid s.n.* 26.iii.1958, Calperum station (AD 97348358); (Holder): *Donner 3693*, 26.ix.1971, c. 15 km W of Waikerie (AD); (Blanchetown): *Barker 4133*, 21.viii.1980, c. 6.5 km SW of Walkers Flat ferry crossing (AD); (Towitta): *Kraehenbuehl 184*, 31.vii.1960, river Marne Gorge (AD): South-East Mallee Heathlands (Billiatt): *Carrick 3306-3309*, 14.xi.1972, Billiatt National Park (AD); (Pinnaroo): *J.M. Black s.n.*, 12.x.1981, Pinnaroo (AD 96909064); (Karoonda): *J.M. Black s.n.*, 10.x.1910, Lameroo (AD 96909004); Moorlands): *Williams 1039*, 2.x.1970, between Malinong & Coomandook (AD); (The Big Desert): *Sharrad 1095*, 29.viii.1961, 30 miles from Pinnaroo (AD); (Cannawigara): *Wilson 2089*, 29.viii.1961, c. 65 km N of Bordertown (AD); (Bordertown): *Hunt 234*, 15.x.1961, c. 5 km NNE of Bordertown (AD); (Loydella): *Conn 1040*, 28.ix.1980, Braendler's scrub (AD); (Wood Hill): *Cleland s.n.*, 12.x.1938, Chauncey's Line (AD 966031506); Northern Calcarenite Ridges and Plains (Catana): *J.M. Black 25*, -.ix.1917, Yumali (AD); (Karoonda): *E. & A. Ashby 228*, -.xi.1940, between Keith and Bordertown (AD): Murray Lakes (Goolwa): *Carrick 2980*, 11.xi.1971, Finniss (AD). —Mt Lofty Block: Peninsula Uplands (Sandergrove): *Cleland s.n.*, 26.xi.1966, Sandergrove scrub (AD 97315375): Kangaroo Island (Mt Marsden): *Crocker s.n.*, 13.xi.1954, Bay of Shoals (ADW 4341); (Amberley): *Conn 1057-1063*, 11.xi.1980, North Coast road, c. 1 km WNW of Playford Highway (AD, MEL); (MacGillivray): *Ising s.n.*, 12.x.1922, MacGillivray (AD 97249325); (Gantheaume): *Crisp 394*, 28.viii.1971, western boundary of Dudley National Park (AD).—[Yorke Peninsula] Gulf Plains (Workurna): *B. Copley 1408*, 29.viii.1967, c. 16 km N of Bute (AD).—[Eyre Peninsula] Northern Myall Plains (Middleback Range): *Lothian & Francis 706*, 18.ix.1960, Middleback ranges (AD); Central Mallee Plains and Dunes (Midgee): *Orchard 2943*, 29.xii.1970, c. 10 km S of Iron Duke (AD); (Cleve): *Lothian s.n.*, 29.vi.1959, 15 km N of Cowell (AD 96322062).

6. **Prostanthera florifera** Conn, *sp. nov.*

Species nova Sectionis Klanderiae. *Frutices* parvi 0.3-1 m. alti. *Rami* et ramuli plus minusve teretes, dense tomentosi. *Folia* sparsim tomentosa usque glabrescentia, glandifera; *petiolus* absens; *lamina* lineari-obovata usque anguste oblonga, 4-10 mm. longa, 0.6-1 mm. lata, basi attenuata, margine integro, apice obtuso usque rotundato. *Pedicellus florum* 3-4 mm. longus, sparsim tomentosus usque glabrescens, *prophyllis* usque ad 1 mm. e basi calycis affixis. *Calyx* 7-12 mm. longus, glaber, glandifera; *tubus* 5-7 mm. longus; *lobi* late deltoidei, 2-5 mm. longi, circa 5-7 mm. lati, margine fimbriato, apice rotundato. *Corolla* 20-26 mm. longa, rubra; *tubus* 12-15 mm. longus, extra in partibus distalibus sparsim tomentosus, intra glaber; *lobi* extra sparsim tomentosi, intra glabrescentes, *abaxialis-mediano* oblongo-obovato, circa 5 mm. longo, 2.5-3 mm. lato, margine plus minusve irregulari, apice obtuso usque rotundato, emarginato, sinu 0.5 mm. longo, *lateralibus* ovatis usque oblongi-ovatis, 3-4 mm. longis, 2-3 mm. latis, margine fimbriato, apice obtuso, *adaxiali-mediano* plus minusve ovato-deltoideo, 7-9 mm. longo, 8-9 mm. lato, margine plus minusve irregulari, fimbriato, apice obtuso. *Stamina* circa 11 mm. e basi corollae affixa; filamenta 8-10 mm. longi; antherae 1.5-2 mm. longae, appendice 1-2.5 mm. longa. *Pistillum* 25-28 mm. longum; ovarium circa 1 mm. longum; stylus circa 25 mm. longus; lobis stigmatis circa 1 mm. longis. *Fructus* coccis 2-2.5 mm. longis.

Holotypus: *Conn 675*, 18.ix.1979, Miccollo Hill, Gawler Ranges (Western Pastoral), northern Eyre Peninsula, South Australia (AD; iso in BRI, CANB, K, MEL, NSW, PERTH).

Small, ± densely branched shrub, 0.3-1 m high. *Branches* ± terete, densely tomentose, at least some leaves clustered on short branches. *Leaves* very sparsely hairy, especially medially and basally, to glabrescent, glandular; *petiole* absent; *lamina* linear-obovate to narrowly oblong, 4-10 x 0.6-1 mm [length to width ratio 7.4-11.3, distance of maximum width from base to total lamina length 0.61-0.88], ± flat, thick; base attenuate; margin entire; apex obtuse to rounded; venation not visible. *Pedicel* 3-4 mm long, sparsely hairy to glabrescent; *prophylls* inserted up to 1 mm from base of calyx, hence overlapping basal part of calyx,

Fig. 64. *Prostanthera florifera.*—A. twig and flowers; B. glands on branch; C. open corolla; D. stamens—ventral and dorsal views; E. open calyx to show mericarps, style and stigma (all *Whibley 387*).

narrowly oblong to linear-ovate c. 3 mm long, slightly concave, both surfaces glabrous, rarely with an occasional hair; margin sparsely fimbriate; apex obtuse. *Calyx* 7-12 mm long, glabrous, glandular; *tube* 5-7 mm long, 5-6 mm wide at mouth; *lobes* broadly triangular 2-5 mm long, c. 5-7 mm wide at base; margin fimbriate; apex rounded. *Corolla* 20-26 mm long; outer surface of tube pink-red; inner surface pale pink with tinge of white or with pink-red blotches; inner surface of lobes white with dark brown blotches or sometimes yellow-brown with pink spots; *tube* 12-15 mm long; outer surface sparsely tomentose distally; inner surface glabrous, with a few scattered glandular hairs distally; *lobes* sparsely tomentose on outer surface, glabrescent on inner surface; *abaxial median lobe* oblong-obovate, c. 5 mm long, 2.5-3 mm wide at base; margin ± irregular; apex obtuse to rounded, emarginate; sinus 0.5 mm long; *lateral lobes* ovate to oblong-ovate, 3-4 mm long, 2-3 mm wide at base; margin fimbriate; apex obtuse; *adaxial median lobe-pair* ± ovate-deltoid, 7-9 mm long, 8-9 mm wide at base; margin ± irregular, fimbriate, at least basally and distally; apex obtuse. *Stamens* inserted c. 11 mm above base of corolla; filaments 8-10 mm long, glandular with stalked glands and broad triangular glandular trichomes; anthers 1.5-2 m long; lobes with a minute basal acumen; one side of connective basally extended to form a long slender appendage 1-2.5 mm long, with a few triangular trichomes on appendage. *Pistil* 25-28 mm long; ovary c. 1 mm long, diameter c. 1 mm at base, lobes small, c. 0.5 mm long; style c. 25 mm long; stigma lobes c. 1 mm long. *Mericarps* 2-2.5 mm long, distally 1-1.5 mm extended beyond base of style. Figs 64 & 65.

Distribution: South Australia—Western Pastoral (Gawler and Uno Ranges).

Conservation status: not presently endangered—Risk code = 3V.

Ecology

Occurs on rocky precambrian porphyric (Twidale 1968) rhyodacite derived soils with scattered shrubs of *Acacia sowdenii*, *A. montana*, *Eremophila interstans*, *Melaleuca uncinata*, spinifex (*Triodia*), *Isopogon*, *Calytrix* and ephemerals, especially on hills in rocky places towards ridge tops. Usually occurring at higher altitudes than *Dodonaea viscosa* (Sapindaceae). Soils silty.

Note

This species is closely related to *P. aspalathoides* (refer pp. 305-310) and the relationship between these two is graphically presented in the canonical variate scattergrams and the nearest neighbour phenogram (Figs 7-9 [*P. florifera* = D, *P. aspalathoides* = 1-4]. *P. florifera* is most readily distinguished from the latter species by having longer anther appendages [1-2.5 mm long *cf.* up to 0.3 (-0.5) mm in *P. aspalathoides*]. Several other characters are larger and/or longer in *P. florifera* than *P. aspalathoides*. For example, *P. florifera* tends to have longer pedicels (3-4 mm *cf.* 2-3 mm), longer calyces (7-12 mm *cf.* 5-7 mm [longer calyx tube: 5-7 mm*cf.* 3-4 mm]), longer corolla (20-26 mm *cf.* 10-20 mm [longer corolla tube: 12-15 mm *cf.* 8-11 mm]), longer abaxial median corolla lobe (c. 5 mm *cf.* 2-3 mm), and longer style (c. 25 mm *cf.* 15-20 mm). The collections from the Uno Range tend to have smaller leaves (more typical of *P. aspalathoides*) than those from the Gawler Ranges.

Selected specimens examined (c. 50 collections)

SOUTH AUSTRALIA.—[northern Eyre Peninsula] Western Pastoral (Uno Range): *Donner 8088*, *8095*, 23.ix.1981, eastern side of main range, southern end (AD); *Whibley 7864*, *7870*, 24.ix.1981, north-western end of range (AD); *Whibley 7962*, 25.ix.1981, c. 10 km E of Uno Station (AD): (Gawler): *Barker 3583*, 24.ix.1978, c. 18 km NNE of Peterby Tank (AD); *Conn 675*, 18.ix.1979, Miccollo Hill (AD); *Conn 679*, 19.ix.1979, Mt Yardea (AD, MEL); *Conn 680*, 19.ix.1979, Kododo Hill (AD, MEL); *B. Copley 2093*, *2095*, 31.viii.1968, c. 25 km E of

Yardea homestead (AD); *B. Copley 2739*, 1.viii.1969, c. 9 km W of Yardea homestead (AD); *Crawford s.n.*, 16.x.1968, NE of Buckleboo (AD, ADW); *Donner 3227*, 28.ix.1969, Mt Ive (AD); *Gardiner s.n.*, 5.viii.1969, Spring Hill, c. 90 km NW of Kimba (AD); *Haegi 732*, 17.x.1975, c. 25 km NNW of Kimba (AD); *Haegi 756*, 17.x.1975, c. 50 km NNW of Minnipa (AD); *Haegi 831*, 21.x.1975, Mt Yardea (AD); *Lay 687*, 29.ix.1972, c. 5 km S of Yarna homestead (AD); *Newman s.n.*, -.ix.1962, Hiltaba Station (AD); *Orchard 980* 26.vii.1968, Mt Partridge (AD); *Orchard 1789*, *1796*, 27.x.1968, c. 40 km N of Minnipa (AD); *Orchard 2168*, 15.viii.1969, SW part of Yandinga Gorge (AD); *Orchard 2230*, 26.ix.1969, Yandinga Gorge (AD); *Orchard 2329*, 28.ix.1969, c. 5 km E of intersection of Yardea, Nonning and Kingoonya roads (AD); *Reichstein 1581*, 28.viii.1973, Nonning Station (AD); *Rohrlach 422*, Peterlumbo (AD); *Rohrlach 497*, 3.ix.1959, E corner of sect. 31, Pinkawillinie (AD); *Rohrlach 785*, 27.viii.1960, c. 2 km NW of Pile Pudla Dam (AD); *Rohrlach 907*, 17.ix.1961, Thurlga Station (AD); *Spooner 2524*, 8.ix.1972, Kododo Hill (AD); *Symon 8040*, *8045B*, 1.x.1972, near summit of Mt Nott (ADW); *Symon 8173*, 5.x.1972, 2 km NW of Dancing Bob Dam (ADW); *Symon 8175*, 5.x.1972, Waltinga Dam (ADW); *Symon 8189*, 6.x.1972, 6 km NW of Pine Lodge (ADW); *Whibley 387*, 15.x.1958, 6 km NW of Minnipa-Yardea road (AD); *Whibley 797*, 27.ix.1960, c. 25 km NNW of Kimba, along Hundred line Gunyarie and Cortlinye (AD); *Wilson 279*, 7.x.1958, 13 km SW of Buckleboo railway Siding (AD); *Wilson 555*, 17.x.1958, Mt Yardea (AD).

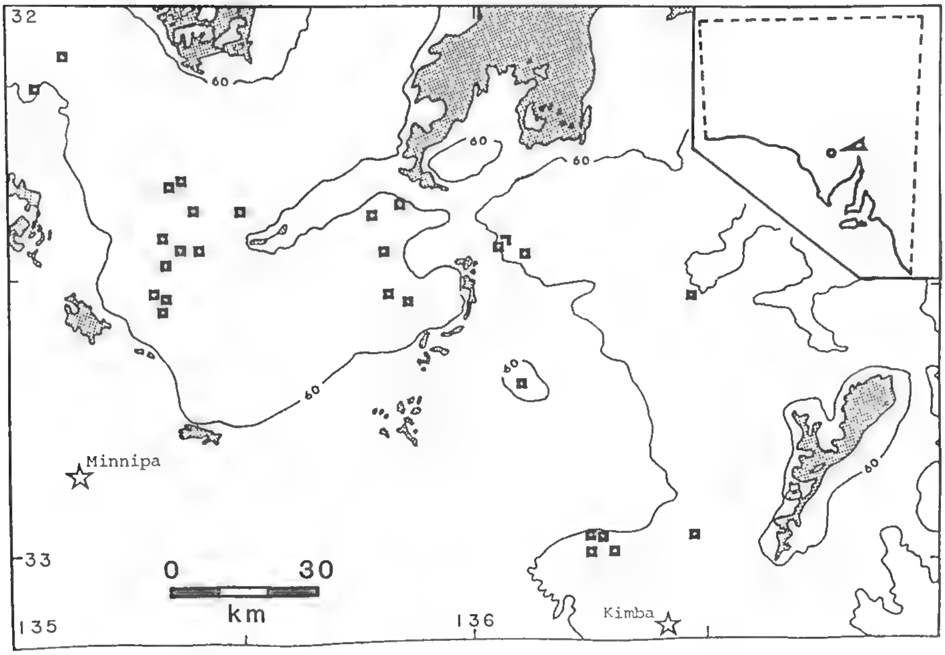


Fig. 65. Distribution map of *Prostanthera florifera*. Stippled areas = lakes or salt pans; contour lines (60 m). Locality of Gawler Ranges and Uno Range given in insert map.

7. Prostanthera pedicellata Conn, *sp. nov.*

Species nova Sectionis Klanderiae. *Frutices* parvi 0.3-1 m. alti. *Rami* et ramuli teretes usque subteretes, saepe internodiis iuvenibus leviter sulcatis, glabris, dense glandiferis. *Folia* glabra, glandifera; *petiolus* absens aut si praesens tum minus quam 1 mm. longus; *lamina* angusta, ovata, oblonga usque obovata, (3-) 5-8 (-11) mm. longa, 1.5-2.5 mm. lata, basi attenuata, margine integro parum incrassato, saepe parum recurvo, apice obtuso, saepe recurvo. *Pedicellus florum* 8-15 mm. longus, ad basim glaber, alibi sparsim tomentosus, *prophyllis* 1-5 mm. e basi calycis affixis. *Calyx* 6-8 mm. longus, extra tomentosus; *tubus* 4-5 mm. longus, intra glaber; *lobi* plus minusve deltoidei, 2.5-3 mm. longi, 3-4 mm. lati, intra glabri praeter ad marginem sparsim tomentosi, raro glabri, apice obtuso usque subacuto. *Corolla* 20-25 mm. longa, rubra, extra in partibus distalibus tomentosa, saepe dense; *tubus* 11-15 mm. longus; *lobi* intra sparsim pilosi, *abaxiali-mediano* plus minusve ovato, 3-5 mm. longo, circa 2 mm. lato, recto usque recurvo, margine integro, apice subacuto usque obtuso, *lateralibus* plus minusve deltoideis usque ovatis, circa 2 mm. longis, margine integro, *adaxiali-mediano* late oblongo usque subovato, interdum late ovato, 5-6 mm. longo, (6-) 8-10 mm. lato, margine integro, apice rotundato, plerumque emarginato, sinu usque ad 1 mm. longo. *Stamina* circa 10 mm. e basi corolla affixa; filamenta 10-12 mm. longi; antherae 2-2.5 mm. longae, appendice absens aut si praesens tum minus quam 0.1 mm. longa. *Pistillum* 25-30 mm. longum; ovarium circa 0.6 mm. longum; stylus 20-25 mm. longus; lobis stigmatis usque ad 0.5 mm. longis. *Fructus* coccis 2-3 mm. longis.

Holotypus: *Ashby 2993*, 3.ix.1969, Pindar, northern Avon (South-West), Western Australia (AD; iso in PERTH).

Small slightly spreading shrub, 0.3-1 m high. Branches terete to subterete, often with faint grooving on distal internodes (from one leaf axis to next node alternately), glabrous, densely glandular; glands ± hemispherical, touching. *Leaves* arranged along branches, not clustered, glabrous, glandular, (2-) 17-87 glands/mm^2; petiole absent or if present then less than 1 mm long, usually indistinct, grooved on adaxial surface; *lamina* narrow, ovate, oblong to obovate, (3-) 5-8 (-11) x 1.5-2.5 mm [lamina length to width ratio 4.6-6.7, distance of maximum width from base of lamina to total lamina length 0.26-0.67]; base attenuate; margin entire, slightly thickened, often slightly recurved; apex obtuse, often recurved; venation indistinct, occasionally base of midrib faintly raised on lower surface. *Pedicel* 8-15 mm long, glabrous basally, sparsely hairy distally, especially above point of insertion of prophylls; *prophylls* inserted 1-5 mm from distal end of pedicel, usually not overlapping basal part of calyx, narrowly oblong to linear-obovate, 2.5-4 x 0.5 mm, slightly concave, glabrous or sparsely hairy; apex obtuse, often slightly recurved. *Calyx* 6-8 mm long, green with maroon tinge distally; outer surface hairy; hairs 0.4-0.6 mm long, white; *tube* 4-5 mm long; inner surface glabrous; *lobes* ± triangular, 2.5-3 mm long, 3-4 mm wide at base; inner surface glabrous basally, sparsely hairy towards margin (rarely glabrous); apex obtuse to subacute. *Corolla* 20-25 mm long, red; outer surface distally hairy, often densely so; *tube* 11-15 mm long; *lobes* sparsely pilose on inner surface; *abaxial median lobe* ± ovate, 3-5 mm long, c. 2 mm wide at base, straight to recurved; margin entire; apex subacute to obtuse; *lateral lobes* ± triangular to ovate, c. 2 mm long; margin entire; *adaxial median lobe-pair* broad-oblong to subobovate, sometimes broad--ovate, 5-6 mm long, (6-) 8-10 mm wide at base; margin entire; apex rounded, usually emarginate; sinus up to 1 mm long. *Stamens* inserted c. 10 mm above base of corolla; filaments 10-12 mm long, with a few scattered, minute ± triangular glandular trichomes; anthers 2-2.5 mm long; base of lobes with small acumen 0.1-0.3 mm long; appendage absent or if present then less than 0.1 mm long. *Pistil* 25-30 mm long; ovary c. 0.6 (-1) mm long, diameter at base c. 1 mm; lobes small, c. 0.3 mm long; style 20-28 mm long; stigma lobes up to 0.5 mm long. *Mericarps* 2-3 mm long, distally c. 1 mm extended beyond base of style; seed unknown. Figs 66 & 68.

Distribution: Western Australia (South-West: Avon).

Conservation status

This species appears to be very rare and the small population at Pindar (Western Australia) is apparently rapidly decreasing in size as its habitat is cleared—Risk Code = 1E.

Ecology

Growing in *Acacia*, *Eremophila*, *Melaleuca* shrubland. Soil a yellow-brown loam with ironstone gravel often present on the surface.

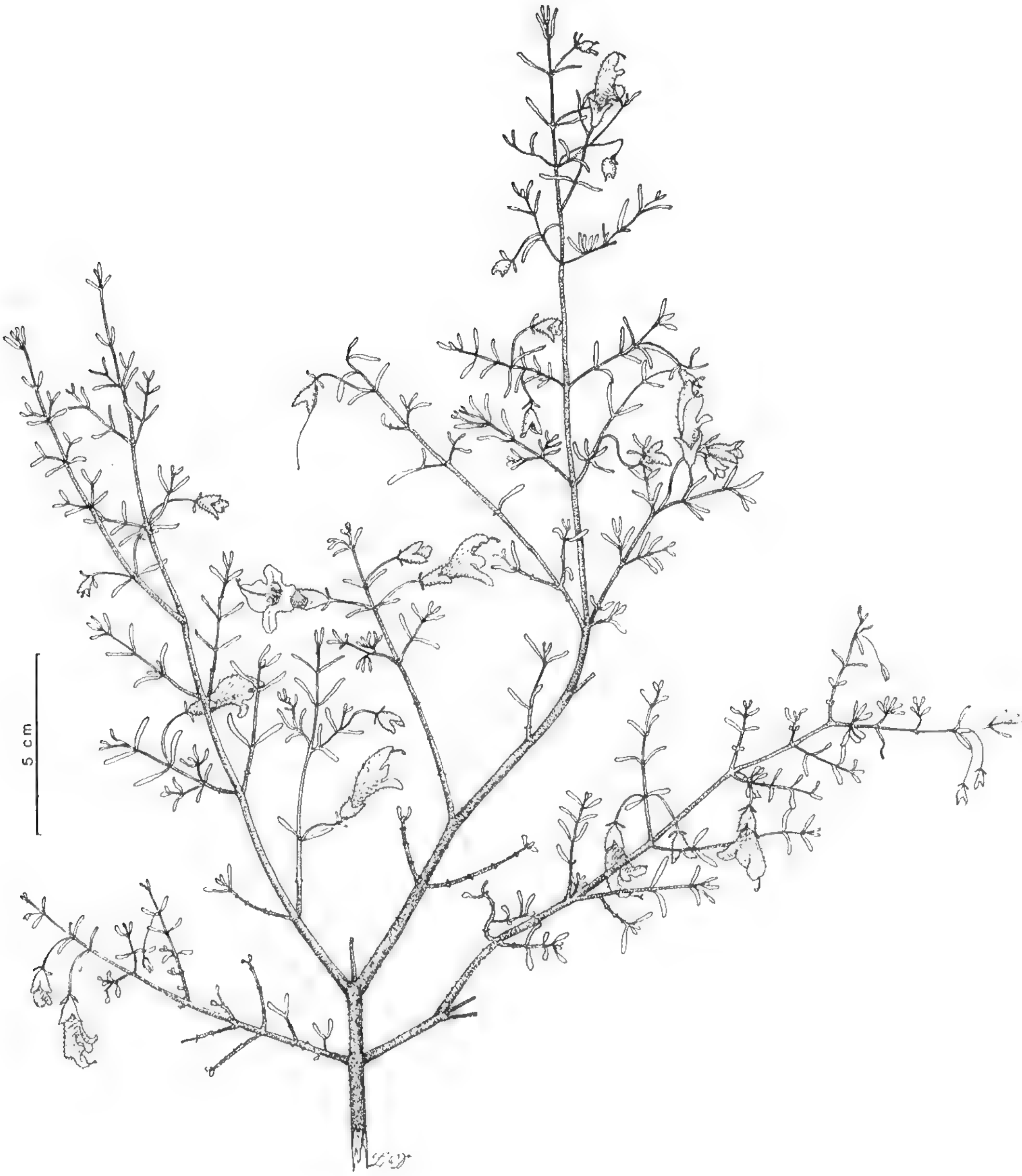


Fig. 66. *Prostanthera pedicellata*.—Twig and flowers (*Ashby 2993*).

Note

This new species has its closest affinities with *P. semiteres*. In particular, there is a superficial similarity between *P. pedicellata* and *P. semiteres* ssp. *intricata*. Both have relatively long pedicels and both lack staminal appendages. *P. pedicellata* differs by having calyces with hairy outer surfaces (glabrous in *P. semiteres*) and broader usually longer leaves (leaves 1.5-2.5 mm wide in *P. pedicellata*, 0.5-1.2 mm wide in *P. semiteres*).

Short 994 (AD), which was collected towards the end of a relatively dry season (15.xi.1979), has leaves similar to *P. semiteres* and so may represent an intermediate specimen between the two taxa. *Ross 2734 & 2735* (MEL) have calyces which are glabrous on their inner surfaces and only have a few scattered hairs on their outer surfaces. In all other respects, these collections are identical with *Ross 2732, 2733, 2736 & 2737* which are all from the same population.

Specimens examined

WESTERN AUSTRALIA.—South-West: northern Avon (Pindar): *Ashby 2993*, 3.ix.1969 (AD, PERTH); *Ashby 5035*, -.ix.1973 (AD); *Ashby 5112*, -.ix.1973 (AD); *Maiden s.n.*, -.x.1909 (NSW 126722, NSW 126726); *Oliver for Ashby 3931*, -.viii.1971 (AD); *Phillips 54467*, 20.ix.1968 (AD); *Ross 2732-2737*, 1.ix.1982 (MEL); *Short 994*, 15.xi.1979 (AD).

8. **Prostanthera incurvata** Conn, *sp. nov.*

Species nova Sectionis Klanderiae. *Frutices* parvi, 0.4-0.7 m. alti. *Rami* et ramuli plus minusve teretes, tomentosi, glandiferi. *Folia* glabra; *petiolus* absens aut si praesens tum minus quam 1 mm. longus; *lamina* complanata angusta, obovata usque oblonga, 5-10.3 mm. longa, 0.8-1.2 mm. lata, saepe incurvata, basi attenuata, margine integro, apice obtuso usque rotundato. *Pedicellus florum* 0.8-1.8 mm. longus, glaber, dense glandifer, *prophyllis* ad basim calycis affixis. *Calyx* 6-8 mm. longus, extra glaber, intra ad basim glaber, alibi dense tomentosus; *tubus* 4-5 mm. longus; *lobi* late deltoidei, (1.5-) 2 mm. longi, 3.5-4 mm. lati, margine integro, apice obtuso. *Corolla* 15-20 mm. longa, rosea usque rubra, interdum lutea, extra in partibus distalibus moderate usque dense tomentosa, intra glabra usque glabrata; *tubus* circa 10 mm. longus; *lobus abaxiali-medianus* plus minusve obovatus, 3-3.5 mm. longus, rectus usque recurvus, margine integro, apice obtuso, *lateralibus* oblongo-ovatis, 2-2.5 mm. longis, margine integro, apice obtuso usque rotundato, *adaxiali-mediano* plus minusve obovato, circa 3 mm. longo, recto, margine integro usque parum irregulari, apice obtuso, emarginato, sinu 1-1.5 mm. longo. *Stamina* 7-8 mm. e basi corollae affixa; filamenta 6-7 mm. longa; antherae 1.5-1.8 mm. longae, appendice absenti. *Pistillum* 20-23 mm. longum; ovarium 0.6-0.8 mm. longum; stylus 18-20 mm. longus; lobis stigmatis circa 1 mm. longis. *Fructus* coccis circa 2 mm. longis.

Holotypus: *N.T. Burbidge 2664*, 19.ix.1947, Pioneer rock, N of Lake Cowan, Western Australia (PERTH, iso in CANB).

Small shrub, 0.4-0.7 m high. *Branches* ± terete, hairy (rarely glabrous); hairs usually ± restricted to two opposite longitudinal grooves, 80-190 (-270) hairs/mm^2, 0.09-0.3 mm long, ± erect [base of hair to first bend 0.04-0.07; greatest distance hair from branch is 0.04-0.16 mm], white, moderately dense-glandular, 56-109 glands/mm^2; glands hemispherical. *Leaves* usually clustered on short lateral shoots, sometimes arranged along the branches, glabrous; *petiole* absent or if present then less than 1 mm long; *lamina* flattened, narrow, obovate to oblong, 5-10.3 x 0.8-1.2 mm [length to width ratio 4.9-14; distance of maximum width from base of lamina to total lamina length 0.2-0.8], frequently incurved; base attenuate; margin entire; apex obtuse to rounded; venation indistinct; midrib region often slightly sunken on adaxial surface. *Pedicel* 0.8-1.5 (-2) mm long, ± terete, light green, glabrous, densely glandular; *prophylls* inserted at base of calyx (rarely up to 0.3 mm from base of calyx), hence overlapping with base of calyx, ± narrowly ovate, 1.7-4.2 (-4.7) x c. 0.6 mm [length to width ratio 3.4-7 (-8.4)], glabrous; margin entire; apex obtuse to subacute. *Calyx* 6-8 mm long, green; outer surface glabrous, moderately to densely glandular; glands hemispherical, 40-133 glands/mm^2; inner surface glabrous basally, densely hairy (indumentum tomentose to pubescent) in mouth and on lobes, (51-) 100-c. 400 hairs/mm^2; hairs weak, ± curled, entangled, usually less than 0.08 mm long,

Fig. 67. *Prostanthera incurvata*.—Twig and flowers (*Phillips CBG 23260*).

white; *tube* 4-5 mm long; *lobes* broadly triangular, (1.5-) 2 mm long, 3.5-4 mm wide at base [calyx lobe to tube ratio 0.5-0.8]; margin entire; apex obtuse. *Corolla* 15-20 mm long, pink to red, sometimes yellow; outers surface moderately to densely hairy distally (70-100 hairs/mm²); hairs 0.3-0.4 mm long, white; inner surface glabrous, sometimes with an occasional hair near margin; *tube*; c. 10 mm long; *abaxial median lobe* ± obovate, 3-3.5 mm long, extended forward to recurved; margin entire; apex obtuse; *lateral lobes* oblong-ovate, 2-2.5 mm long; margin entire; apex obtuse to rounded; *adaxial median lobe-pair* ± obovate, c. 3 mm long, extended forward; margin entire to slightly irregular; apex obtuse, emarginate; sinus 1-1.5 mm long. *Stamens* inserted 7-8 mm from base of corolla; filaments 6-7 mm long, glandular triangular trichomes present; anthers 1.5-1.8 mm long; base of lobes with minute acumen c. 0.1 mm long; appendage absent. *Pistil* 20-23 mm long; ovary 0.6-0.8 mm long, lobes small, c. 0.1 mm long; style 18-20 mm long; stigma lobes c. 1 mm long. *Mericarps* c. 2 mm long (possibly immature), distally extended c. 0.8 mm beyond base of style. Figs 67 & 68.

Distribution: Western Australia (Eremaean: Austin, Coolgardie).

Conservation status: The conservation status of this species is not known—Risk code = 3K.

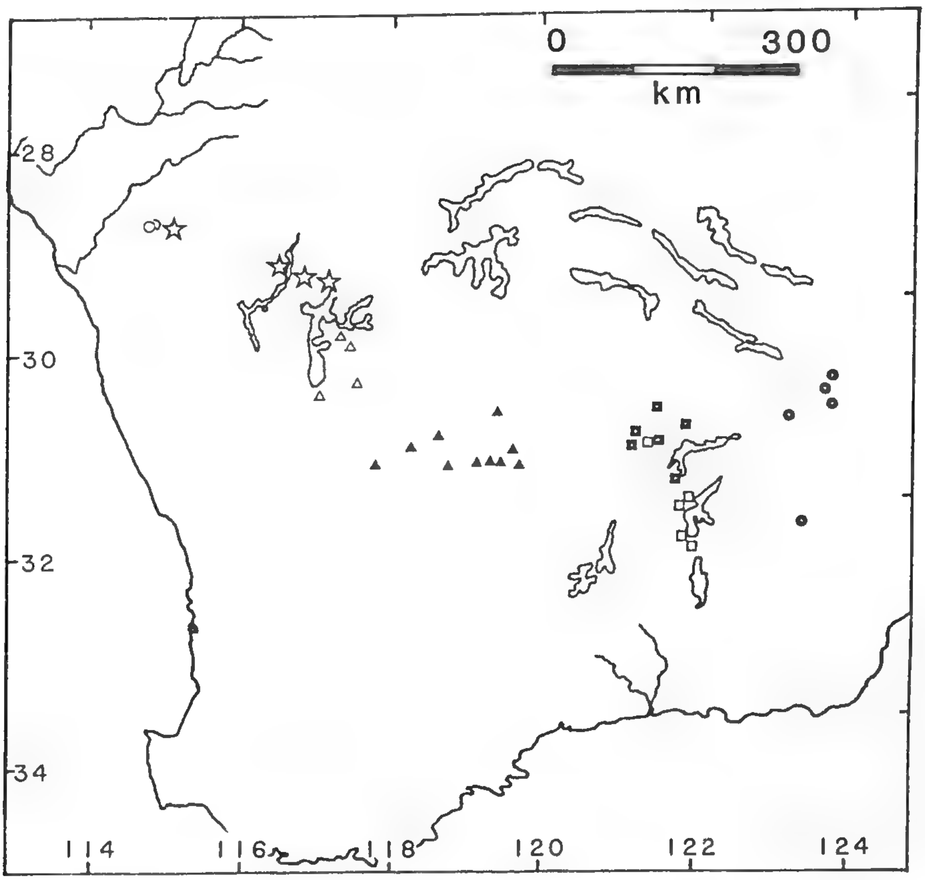


Fig. 68. Distribution map of the *Prostanthera laricoides* complex. ● *P. laricoides*; ■ *P. incurvata*; □ *P. incurvata* (hairy branches); ▲ *P. semiteres* ssp. *semiteres*; △ *P. semiteres* ssp. *intricata*; ☆ *P. patens*; ○ *P. pedicellata*.

Ecology

Only three collectors have made notes on the ecology of this species. Near Londonderry it occurs as rare shrub in *Eucalyptus longicornis* open low woodlands on a moderately exposed stony greenstone ridge in well-drained stony loam soil (*Newbey 6123*). At Mount Hunt it occurs on serpentinites (*Bale 123*), whereas at Lake Cowan it occurs in red sands (*Broadbent 1054*).

Note

This new species is closely related to *P. semiteres*. However, *P. incurvata* has a shorter pedicel [0.8-1.5 (-2) mm *cf.* 3-15 mm in *P. semiteres*], smaller usually incurved leaves, a larger lamina length to width ratio, is more glandular and hairier than *P. semiteres*. However, *Cronin s.n.* (MEL 1512008) is glabrous. For further discussion on this species refer 'Numerical analysis of the *Prostanthera laricoides* complex' and 'Morphological variation in the *Prostanthera laricoides* complex'.

Specimens examined

WESTERN AUSTRALIA.—Eremaean: Austin: *Bale 123*, -.x.1965, Mt Hunt, near Boulder (PERTH).—Coolgardie: *Beard 3371*, 26.v.1964, S of Coolgardie (KP); *Blackall 979*, -.x.1931, 25 miles N of Norseman (PERTH); *Broadbent 1054*, 23.vii.1953, Lake Cowan (NSW); *N. Burbidge 2664*, 19.ix.1947, Pioneer Rock, near Lake Cowan (CANB); *Canning CBG 26146*, 6.ix.1968, 22 miles from Coolgardie, towards Norseman (AD 96920342); *Chinnock 3055*, 15.ix.1976, Mt Monger (AD); *Cronin s.n., anno* 1893, between upper Blackwood River and Lake Lefroy (MEL 1512008); *Helms s.n.*, -.vi.1898, Coolgardie (NSW 126727); *Helms s.n.*, -.vii.1899, Coolgardie (K, PERTH); *Kemsley s.n.*, -.v.1952, Kambalda (MEL 43820); *Lidgey 5 & 7*, 22.viii.1900, Hampton plains, near Coolgardie (K); *Newbey 6123*, 28.ix.1979, 13 km W of Londonderry (PERTH); *Phillips CBG 20619*, 11.ix.1962, c. 75 miles N of Norseman (AD 96915102); *Phillips CBG 23260*, 4.ix.1968, Spargoville (AD 96918133); *Phillips CBG 23274*, 4.ix.1968, ?Beacon Hill, Norseman (AD 96918148); *Wilson 3112*, 14.ix.1964, near Londonderry (AD).

9. **Prostanthera semiteres** Conn, *sp. nov.*

Species nova Sectionis Klanderiae. *Frutices* parvi, usque ad 1.4 m. alti. *Rami* et ramuli plus minusve teretes, glabri. *Folia* glabra; *petiolus* absens aut si praesens tum usque ad 0.3 mm. longus; *lamina* angusta, obovata usque oblonga, 2-12 mm. longa, 0.5-1.1 mm. lata, basi attenuata, margine integro, apice obtuso. *Pedicellus florum* 3-15 mm. longus, glaber, *prophyllis* usque ad 2.5 mm. e basi calycis affixis. *Calyx* 5-7.3 mm. longus, extra plerumque glaber; *tubus* 4-6 mm. longus, intra glaber vel tomentosus; *lobi* transverse angusto-deltoidei, 0.5-2 mm. longi, 3-5 mm. lati, intra in partibus distalibus tomentosi, margine integro, apice obtuso. *Corolla* 16-25 mm. longa, rubra vel rosea, extra in partibus distalibus tomentosus; *tubus* 6-14 mm. longus; *lobus abaxiali-medianus* plus minusve obovatus, oblongo-ovatus usque deltoideus, 2-3.5 mm. longus, recurvus usque reflexus, margine integro, apice obtuso usque rotundato, *lateralibus* oblongis, vel latis et ovatis usque deltoideis, 1-3 mm. longis, erectis usque recurvis, margine integro, apice subacuto usque obtuso, *adaxiali-mediano* lato, ovato usque obovato, 3-5 mm. longo, margine integro, apice obtuso, emarginato, sinu usque ad 1.5 mm. longo. *Stamina* 7.5-9 mm. e basi corollae affixa; filamenta 4-8 mm. longa; antherae 1.2-2 mm. longae, appendice absenti. *Pistillum* 22-27 mm. longum; ovarium 0.5-0.8 mm. longum; stylus 21-25 mm. longus; lobis stigmatis 0.1-0.7 mm. longis. *Fructus* coccis 2-3 mm. longis.

Holotypus: *Chinnock 3132*, 20.ix.1976, 2.9 km E of Campion, on Warralakin road, South-West botanical district, Western Australia (AD).

Small shrub, up to 1.4 m high. *Branches* ± terete, glabrous. *Leaves* arranged along main axes and branches, not clustered along short axes, glabrous; *petiole* absent or if present, then up to 0.3 mm long; *lamina* narrow, obovate to oblong, 2-12 x 0.5-1.2 mm; base attenuate; margin entire; apex obtuse; venation indistinct; midrib usually slightly sunken on adaxial surface. *Pedicel* 3-15 mm long, glabrous; *prophylls* inserted up to 3 mm from base of calyx, narrow, oblong to obovate, 1.5-3 (-4.1) x 0.2-0.5 mm [length to width ratio 3.5-8.7], often incurved, becoming recurved to reflexed, glabrous; margin entire; apex obtuse. *Calyx* 5-7.3 mm long; outer surface usually glabrous, glandular; *tube* 4-6 mm long; inner surface glabrous or hairy distally; *lobes* transversely narrow-triangular, 0.5-2 mm long, 3-5 mm wide at base, glabrous at base, hairy distally; margin entire; apex

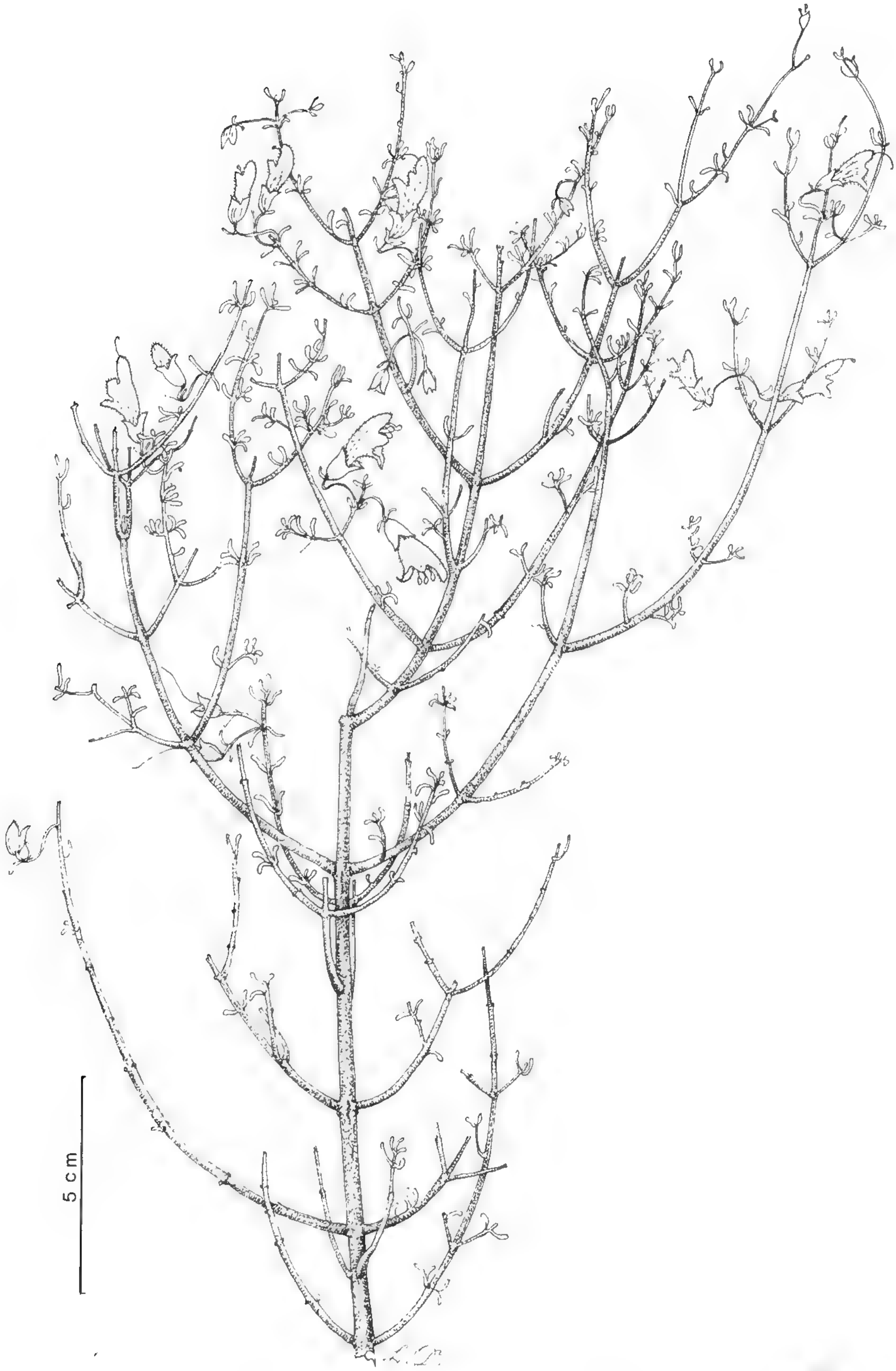


Fig. 69. *Prostanthera semiteres* ssp. *intricata*.—Twig and flowers (*Ashby 3585*).

obtuse. *Corolla* 16-25 mm long, red or pink; outer surface hairy distally, 35-48 hairs/mm^2; *tube* 6-14 mm long; inner surface glabrous; *abaxial median lobe* ± obovate, oblong-ovate to triangular, 2-3.5 mm long, recurved to reflexed; margin entire; apex obtuse to rounded; *lateral lobes* oblong, or ovate to triangular, 1-3 mm long, erect to recurved; margin entire; apex subacute to obtuse; *adaxial median lobe-pair* broad, ovate to obovate, 3-5 mm long; margin entire; apex obtuse, emarginate; sinus up to 1.5 mm long. *Stamens* inserted 7.5-9 mm from base of corolla; filaments 4-8 mm long; anthers 1.2-2 mm long; base of lobes with a minute acumen up to 0.2 mm long; appendage absent. *Pistil* 22-27 mm long; ovary 0.5-0.8 mm long, diameter up to 1.2 mm at base, lobes small, 0.1-0.2 mm long; style 21-25 mm long; stigma lobes 0.1-0.7 mm long. Mericarps 2-3 mm long, distally 1-1.7 mm extended beyond base of style. Figs 68 & 69.

Distribution

Western Australia (Eremaean: Austin, Coolgardie; South-West: Avon).

Conservation status: Considered not at risk.

Note

This species has its closest affinities with *P. pedicellata* (refer p. 316 for details). It is also closely related to *P. incurvata*. However, it is readily distinguishable from the latter species by its longer pedicels [3-15 mm long *cf.* 0.8-1.5 (-2) mm in *P. incurvata*], usually larger leaves and smaller lamina length to width ratio. For further discussion of this species refer 'Numerical analysis of the *Prostanthera laricoides* complex' and 'Morphological variation in the *Prostanthera laricoides* complex'.

The north-western populations of *P. semiteres* (Fig. 68) have noticeably longer pedicels and smaller leaves than the more south-eastern ones. The former group is recognized as a distinct subspecies (*viz. P. semiteres* ssp. *intricata*). The key differences between the two subspecies are summarized below.

Key to subspecies

1a. Pedicel up to 5.5 mm long; prophylls inserted up to 1 mm from base of calyx; leaves (5.5-) 9-11 mm long; calyx lobes to calyx tube ratio 0.14-0.43 .... 9.1 ssp. *semiteres*

1b. Pedicel 7-15 mm long; prophylls inserted (1.5-) 2-3 mm from base of calyx; leaves 2-6 mm long; calyx lobes to calyx tube ratio 0.3-0.56 .... 9.2 ssp. *intricata*

9.1 ssp. semiteres

Small shrubs, up to 1.4 m high. *Lamina* narrow, obovate to oblong, 8-12 x 0.7-1.1 mm [length to width ratio 8-17 (-20); ratio of distance of maximum width from base to total lamina length (0.05-) 0.4-0.8]. *Pedicel* 3-4 (-5.5) mm long, green, often with purple tinge; *prophylls* inserted up to 1 mm from base of calyx. *Calyx* green or purple-green; outer surface glabrous, glandular, (17-) 22.5-65 (-83.3) glands/mm^2; *tube* glabrous; *lobes* 0.5-1.5 mm long, c. 5 mm wide at base [calyx lobe to tube ratio 0.14-0.43]; inner surface hairy distally, (3-) 41-147 (-253) hairs/mm^2. *Corolla tube* 6-12 mm long. *Staminal filaments* 4-6.5 mm long. *Stigma lobes* 0.1-0.4 mm long. Fig. 68.

Distribution: refer Fig. 68.

Ecology

Occurs amongst granitic rocks (*Beard 4744, 5944*), in granitic sandy loams (*Chinnock 3132*), on schistose hills (*Gardner 2797*), and in red clay-loams (*George 2670*).

Specimens examined

WESTERN AUSTRALIA:—Eremaean: Coolgardie: *Anon s.n.*, 21.x.1895, Southern Cross (PERTH); *Beard 4744*, 17.vii.1967, 20 miles W of Bullfinch (A, PERTH); *Beard 5091*, -.viii.1967, Warralackin-Bullfinch area (KP); *Beard 5944*, 19.vii.1970, 6 miles N of Weowanie Rock (KP, PERTH); *Blackall 896*, 13.xi.1931, by salt lake at Southern Cross (PERTH); *Demarz 5261*, 10.x.1974, 4 miles N of 242 mile peg on Great Eastern Highway (KP, PERTH); *Gardner 2797*, -.ix.1931, Lake Polaris, Southern Cross (K, PERTH); *George 2670*, 20.viii.1961, c. 28 miles E of Southern Cross (PERTH); *Newbey 2538*, 5.ix.1966, Koolyanobbing Range (PERTH); *Newbey 5712*, 20.vii.1979, 0.5 km N of Southern Cross (PERTH); *P. Wilson 3508*, 23.ix.1964, 9 km E of Southern Cross (AD); *P. Wilson 3515*, 23.ix.1964, 16 km E of Southern Cross (AD).—South-West: Avon: *Chinnock 3132*, 20.ix.1976, 2.9 km E of Campion (AD); *Gardner 2060*, 6.x.1927, Noongar (K, PERTH).

9.2 **ssp. intricata** Conn, *ssp. nov.*

Frutices parvi, circa 0.3 m. alti. *Lamina* angusta, oblonga usque obovata, 2-6 mm. longa. *Pedicellus florum* 7-15 mm. longus, *prophyllis* 2-2.5 mm. e basi calycis affixis. *Lobis calycis* 1-2 mm. longi, circa 3 mm. lati. *Tubus corollae* 9-14 mm. longus. *Filamenta staminum* 6-8 mm. longa. *Lobi stigmatis* 0.5-0.7 mm. longi.

Holotypus: *Ashby 3585*, 7.ix.1970, Beacon, South-West botanical district, Western Australia (PERTH; iso in AD).

Small shrub, c. 0.3 m high. *Lamina* narrow, oblong to obovate, 2-6 x 0.5-1 mm [length to width ratio 5-9.6; ratio of distance of maximum width from base to total lamina length up to 0.66]. *Pedicel* 7-15 mm long, maroon or dark green with tinge of red; *prophylls* inserted (1.5-) 2-3 mm from base of calyx. *Calyx* green, often dark green and/or with tinge of maroon distally; outer surface glabrous or rarely with an occasional hair distally, 0 (-3) hairs/mm², moderately glandular 20-46 glands/mm²; inner surface moderately to densely hairy, 34-106 hairs/mm²; *lobes* 1-2 mm long, c. 3 mm wide at base [calyx lobe to tube ratio 0.3-0.56]. *Corolla tube* 9-14 mm long. *Staminal filaments* 6-8 mm long. *Stigma lobes* 0.5-0.7 mm long. Figs 68 & 69.

Distribution: refer to Fig. 68.

Ecology: not known.

Note

This subspecies is easily distinguished from ssp. *semiteres* by its long pedicels [7-15 mm long *cf.* up to 5.5 mm in ssp. *semiteres*] and short leaves [2-6 mm long *cf.* (5.5-) 9-11 mm in ssp. *semiteres*]. It is superficially similar to *P. pedicellata*, however the usually glabrous outer surface of the calyx, the densely hair inner surface of the calyx, and the small calyx lobe to tube ratio readily distinguish this subspecies from the latter species.

Specimens examined

WESTERN AUSTRALIA.—Eremaean: Austin: *Weber 5188*, 18.x.1975, c. 15 km E of Mouroubra Homestead (AD).—Coolgardie: Mt Churchman: *Blackall 3432*, *3452*, 13.x.1937 (PERTH); *Rosier 309*, 17.ix.1963 (PERTH); *Young s.n.*, *s. dat.* (MEL 43397).—South-West: Avon: *Ashby 3585*, 7.ix.1970, Beacon (AD, PERTH); *Harvey & Rosier 251*, -.x.1960, Mollerin (PERTH).

10. **Prostanthera laricoides** Conn, *sp. nov.*

Species nova Sectionis Klanderiae. *Frutices* parvi, 0.6-1.2 m. alti. *Rami* et ramuli plus minusve teretes, partim dense tomentosi, pilis 0.1-0.2 mm. longis, dense glandiferi, internodiis iuvenibus parum complanatis. *Folia* glabra, dense glandifera; *petiolus* absens; *lamina* teretes, interdum pagina adaxiali leviter sulcata, (5-) 10-18 (-20) mm. longae, 0.4-0.7 mm. latae, basi attenuata, margine integro, apice obtuso usque rotundato. *Pedicellus florum* circa 1 mm. longus, dense tomentosus, *prophyllis* ad basim calycis affixis, mox caducis. *Calyx* 4-6 mm. longus, extra parum tomentosus, pilis usque ad 0.1 mm. longis, intra ad basim glaber, alibi parum tomentosus, pilis (0.07-) 0.1-0.2 mm. longis; *tubus* 3-4.5 mm. longus; *lobi* late deltoidei, 1.5-2 mm, longi, circa 3 mm. lati,

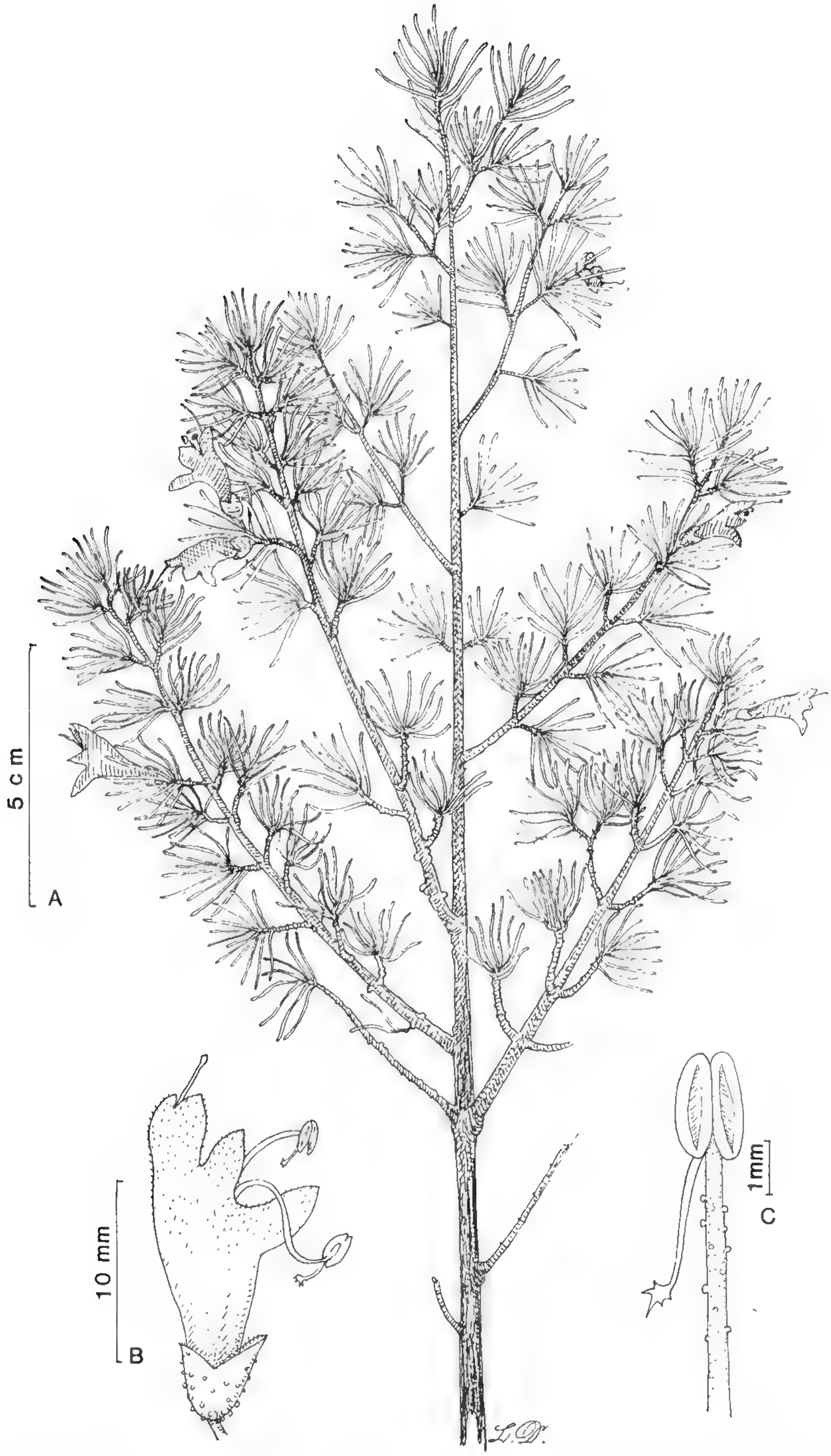


Fig. 70. *Prostanthera laricoides*.—A. twig and flowers; B. flower; C. stamen—ventral view (all *Boswell F66*)

margine, integro, fimbriato, apice rotundato. *Corolla* 14-18 mm. longa, rubra, extra in partibus distalibus sparsim tomentosa; *tubus* 10-12 mm. longus; *lobus abaxiali-medianus* plus minusve oblongo-ovatus, 3-4 mm. longus, 1.5-2.3 mm. latus, margine integro, fimbriato, apice obtuso usque rotundato, *lateralibus* plus minusve late oblongis usque ovatis, circa 2 mm. longis, circa 2 mm. latis, margine integro, fimbriato, apice rotundato, *adaxiali-mediano* late ovato, circa 4 mm. longo, circa 5 mm. lato, margine integro usque parum irregulari, apice plus minusve obtuso, emarginato, sinu usque ad 1 mm. longo. *Stamina* 8.5-10 mm. e basi corollae affixis; filamenta 4-5 mm. longa; antherae 1.5-1.8 mm. longae, appendice (1-) 1.5-2 mm. longa. *Pistillum* 20-22 mm. longum; ovarium 0.5-1 mm. longum; stylus circa 20 mm. longus; lobis stigmatis circa 0.5 mm. longis. *Fructus* coccis 2-2.5 mm. longis.

Holotypus: *Boswell F66*, *anno* 1967, Cundeelee, Helms botanical district, Western Australia (PERTH).

Small shrub, 0.6-1.2 m high. *Branches* ± terete, slightly flattened distally, densely tomentose from within each axil to the next upper node; hairs 0.1-0.2 mm long, densely glandular. *Leaves* clustered (leaf bearing branches 1-4 mm long), glabrous, densely glandular; *petiole* absent; *lamina* terete, sometimes faintly grooved along adaxial surface, (5-) 10-18 (-20) x 0.4-0.7 mm [length to width ratio (12.5-) 17.5-28.5 (-31.25), distance of maximum width from base to total lamina length 0.05-0.86]; base attenuate; margin entire; apex obtuse to rounded; venation not visible. *Pedicel* c. 1 mm long, densely hairy; hairs less than 0.1 mm long, glandular; *prophylls* inserted near distal end of pedicel and so, overlapping basal part of calyx, soon caduous, ± linear, c. 0.5 mm long, concave, glabrous; margin fimbriate; hairs up to 0.2 mm long; apex obtuse. *Calyx* 4-6 mm long; outer surface sparsely minute-hairy, 45-159 hairs/mm^2; hairs up to 0.05-0.1 mm long; inner surface glabrous on basal 2-2.5 mm, sparsely hairy distally, 68-220 hairs/mm^2, hairs (0.7-) 0.1-0.2 mm long; *tube* 3-4.5 mm long; *lobes* broadly triangular, 1.5-2 mm long, c. 3 mm wide at base; margin entire, fimbriate with hairs c. 0.1 mm long; apex rounded. *Corolla* 14-18 mm long, dull light red; outer surface sparsely tomentose distally; hairs up to 0.2 mm long; *tube* 10-12 mm long; *lobes* glabrous on inner surface; *abaxial median lobe* ± oblong-ovate, 3-4 x 1.5-2.3 mm; margin entire, fimbriate; apex obtuse to rounded; *lateral lobes* ± broad-oblong to ovate, c. 2 mm long, c. 2 mm wide at base; margin entire, fimbriate; apex rounded; *adaxial median lobe-pair* broad-ovate, c. 4 mm long, c. 5 mm wide at base; margin entire to slightly irregular, fimbriate; apex ± obtuse, emarginate; sinus up to 1 mm long, up to 2 mm wide distally. *Stamens* inserted 8.5-10 mm above base of corolla; filaments 4-5 mm long, with slightly raised glands; anthers 1.5-8 mm long; one side of connective extended to form a basal appendage (1-) 1.5-2 mm long, broad-triangular trichomes present at distal end of appendage, trichomes c. 0.1 mm long. *Pistil* 20-22 mm long; ovary 0.5-1 mm long, diameter c. 0.5 mm at base, lobes small; style c. 20 mm long; stigma lobes c. 0.5 mm long. *Mericarps* 2-2.5 mm long, distally 1 mm extended beyond base of style. Figs 68 & 70.

Distribution: Western Australia (Eremaean: Helms, Coolgardie).

Conservation status: Considered not at risk.

Ecology

All that is known about the ecology of this species is that it occurs 'on sandy soil among rocks' (*Royce 5371*) near Coonana and on 'moderately exposed sheet deposits of granitic loam to sandy soil on exposed granite bedrock' (*Newbey 7033*) near Sinclair Soak.

Note

The affinities of *P. laricoides* are uncertain. It is similar to *P. patens* in a number of features (e.g. long anther appendages, prophylls inserted near distal end of pedicel, high density of hairs on outer surface of calyx [refer 'Morphological variation in the *Prostanthera laricoides* complex']), but it has long narrow leaves, and indumentum in two rows on opposite 'sides' of branches (similar to *P. incurvata*). Furthermore, the density of glands on all parts, and the lamina length to width ratio are similar to those of *P. incurvata*.

Overall, *P. laricoides* is probably most closely related to *P. incurvata*. For further discussion of this species refer 'Numerical analysis of the *Prostanthera laricoides* complex' and 'Morphological variation in the *Prostanthera laricoides* complex'.

Specimens examined

WESTERN AUSTRALIA.—Helms: *Boswell F66*, *anno* 1967, Cundeelee (PERTH); *Butler s.n.*, 26.i.1959, Queen Victoria Springs (PERTH); *Carrick 3995A*, 8 miles S of Cundeelee, 10 miles N of Zanthus (AD): Coolgardie: *Main s.n.*, 9.xii.1953, Newman Rock (PERTH); *Newbey 7033*, 11.viii.1980, 23 km SE Sinclair Soak (PERTH); *Royce 5371*, 29.i.1956, W of Coonana, on Trans. Line (PERTH); *Royce 5472*, 1.x.1956, 15 miles N of Zanthus, towards Cundeelee (PERTH).

11. **Prostanthera ringens** Benth., in Mitch., J. trop. Austral. (1848) 363; in DC., Prodr. 12 (1848) 700; Fl. austral. 5 (1870) 106; Woolls, Pl. New S. Wales (1885) 83; Tate, Trans. & Proc. Roy. Soc. S. Austral. (1889) 111; Handb. fl. extratrop. S. Austral. (1890) 151, 252; C. Moore, Handb. fl. New S. Wales (1893) 352; Briq., in Engl. & Prantl, Nat. Pflanzenfam. 4: 3a (1895) 220; F.M. Bailey, Queensl. fl. 4 (1901) 1203, 1204; Dixon, Pl. New S. Wales (1906) 232; F.M. Bailey, Compr. cat. Queensl. pl. (1913) 392; Althofer, Cradle of Incense (1978) 92, 99, 129.

Syntypes: [*Drysdale* (Mitchell 1848, p. 359) for] *T.L. Mitchell 577 & 570* [two numbers but only one specimen], 1 & 16.ix.1846, 'Camp 29. Subtropical New Holland' ['on the Maranoa' [river], Bentham (1870)], Queensland (K *n.v.*; NSW 126717). [Refer Notes].

P. leichhardtii Benth., Fl. austral. 5 (1870) 106; Briq., in Engl. & Prantl, Nat. Pflanzenfam. 4: 3a (1895) 220; F.M. Bailey, Queensl. fl. 4 (1901) 1203; Compr. cat. Queensl. pl. (1913) 392; Althofer, Cradel of Incense (1978) 31, 124, 125-129.

Syntypes: *Leichhart s.n.*, -.viii-ix.- [24.x.1844 (interpolated from diary of Leichhardt 1847)], 'The Sandstone Ranges of Bottletree Creek, lat. 26°30'' [long. c. 150°47'E (interpolated from maps of Leichhardt 1847)]', Queensland (K *n.v.*, MEL 43332).

P. lepidota C.T. White, Proc. Roy. Soc. Queensl. 4 (1944) 74; Althofer, Cradle of Incense (1978) 99, 124, 127.

Lectotype (here chosen): *C.T. White 12404*, 13.xi.1943, Enniskillen, Mitchell District, Queensland (BRI 010664 —lower centre; isolecto. A, AD, BRI 010664 [excl. lectotype], BRI 010665, CANB, K *n.v.*, MO, NY, UC).

Bushy shrub up to 2 m high, diameter 1-1.5 m. *Branches* quadrangular, with two pairs of lateral ridges, sparsely to moderately hairy between the ridges from within the leaf axis to the next node, nodes hairy; hairs c. 0.1 mm long, densely glandular; glands hemispherical. *Leaves* glabrous or with a few scattered hairs basally; *petiole* absent or if present then up to 2 (-3) mm long; *lamina* oblong, ovate to obovate, often narrow, 6-15 x (1-) 2-6 mm, ± flat; base ± cuneate; margin entire; apex obtuse, often slightly emarginate when lamina ovate or obovate; venation not visible, occasionally faint; midrib slightly raised on abaxial surface, slightly sunken on adaxial surface, or indistinct. *Pedicel* 1-3.5 mm long, hairy; hairs 0.06-0.1 mm long; *prophylls* inserted near base of pedicel, hence not, or just overlapping base of calyx, broad-oblong, 0.6-c. 1 x c. 0.5 mm, concave; abaxial surface shortly pubescent; adaxial surface glabrous; margin fimbriate; apex obtuse. *Calyx* 6-8 mm long (usually at least 10 mm in fruit); outer surface glabrous; inner surface with a few scattered glandular hairs; margin, and occasionally lobes, minutely fimbriate, especially in bud; *tube* c. 5 mm long; *lobes* broadly triangular, c. 2 mm long, c. 3 mm wide at base; margin entire; apex ± rounded. *Corolla* 14-23 mm long, pale blue-light green (olivaceous), light green-yellow or yellow; *tube* c. 10 mm long, diameter at mouth c. 5 mm; outer surface glabrous basally, at least on that portion enclosed by the calyx, distally sparsely hairy; *lobes* hairy on outer surface; inner surface glabrous; *abaxial median lobe* ± ovate to obovate, (3-) 4-5 mm long, c. 4 mm wide; margin entire, slightly irregular; apex obtuse to rounded; *lateral lobes* ovate-oblong, 2-3 mm long, c 2 mm wide at base; margin irregular; apex obtuse; *adaxial median lobe-pair* ± ovate, 4-9 mm long, 4-6 mm wide at base;

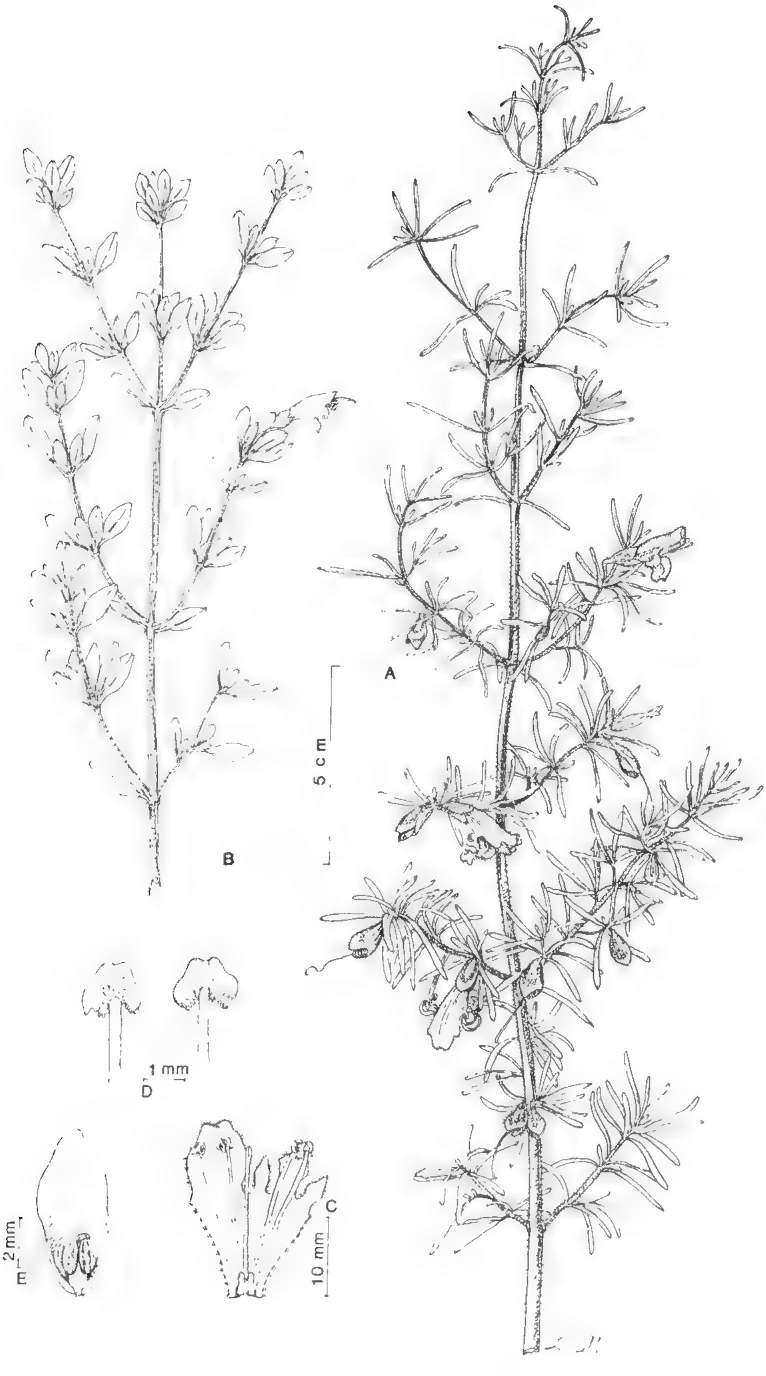


Fig. 71. *Prostanthera ringens.*—A. twig and flowers (*Althofer s.n.*, cultivated material, Burrendong Arboretum); B. twig and flowers (*N. Burbidge 6610*); C. open corolla; D. stamens—ventral and dorsal views; E. part of calyx removed to reveal mericarps (C-D all *Althofer s.n.*).

margin entire to irregular, fimbriate; apex obtuse, sometimes emarginate; sinus up to c. 1 mm long. *Stamens* inserted c. 4 mm from base of corolla; filaments c. 6 mm long, glabrous with a few glandular trichomes; anthers 1.5-2 mm long; base of lobes obtuse, often with a short broad acumen c. 0.1 mm long; appendage absent. *Pistil* 20-25 mm long; ovary 1-1.5 mm long, diameter c. 1 mm at base, lobes small, c. 0.1 mm long; style c. 18 mm long; stigma lobes c. 1 mm long. *Mericarps* 2-2.5 mm long, distally extended c. 1 mm beyond base of style. Figs 71 & 72.

Distribution

Queensland (?Wide Bay or Moreton, Darling Downs, Maranoa, Mitchell), New South Wales (North Western Slopes, Central Western Slopes, North Western Plains, North Far Western Plains).

Conservation status: Considered not at risk.

Ecology

Occurs in rocky sandstone ridges with *Prostanthera striatiflora*, *Eriostemon difformis* and *Eucalyptus morrisii* (at Cobar—*Andrews s.n.*, -.xi.1910), in rocky crevices in tall shrublands with *Acacia doratoxylon* and *Eucalyptus viridis* (near Cobar—*Crisp 4289*), on stony hills with upturned shales and slates (Mt Nurri—*Burbidge 6610*), in red-brown gravelly sand with *Codonocarpus cotinifolius* and *Casuarina cristata* (Yuleba—*Johnson 647*), in stands of *Eucalyptus viridis* dominated Mallee communities (Goonoo forest—*Willis & Althofer s.n.*), and in mixed open forests on shallow hard grey soil (Glenmorgan—*Blake 21268*). Although rare, this species is often locally common. Altitudes 500-c. 600 m.

Notes

The type material of *P. ringens* was collected by Drysdale from near 'Camp 29' (Mitchell 1848, map 4) while Mitchell was exploring north and north-west of this base camp. Whether the collections were made from near the Maranoa river or from the the adjacent ranges is not clear (Mitchell 1848, p. 361). Although it appears that two collections were made on separate days, only one specimen is present on the NSW sheet. According to J. Carrick (*in adnot.*) a part of *Mitchell 577 & 570* was sent from K to NSW in April 1915 (presumably NSW 126717). Whether the K or NSW material individually represent *Mitchell 570* or *577* is not known. Since I have not examined the K material, lectotypification is delayed.

White (1944) incorrectly included *P. lepidota* in section *Prostanthera* [as 'Euprostanthera'] series *Subconcavae* Benth. and he concluded that its closest *affinities* were probably with *P. lithospermoides* F. v. Muell. Although the affinities of *P. ringens* are not clear, it is possibly distantly related to *P. aspalathoides.*

This species is characterized by the more or less flat leaves, the insertion of the prophylls near the base of the pedicel, and by the usually green to blue-green corolla (which is unusual in the prostantheras of Queensland and New South Wales).

There are two more or less distinct forms (*viz.* a broad-leaved group and a narrow-leaved group—Figs 71B & 71A, respectively).

Key to the groups

1a. Leaf lamina length to width ratio (1.5-) 3-5 (-7.5); lamina width (1.5-) 3-4 (-6) mm .. Broad-leaved group

1b. Leaf lamina to width ratio (7.5-) 8-15; lamina width 0.9-1.5 (-2) mm .... Narrow-leaved group

The New South Wales populations of the broad-leaved group are mostly confined to the 'semi-arid' (BSfh) region (Köppen 1936) (≃ warm semi-arid [DB'd] region, Thornthwaite, 1933), refer figure 72. The narrow-leaved group is mostly confined to the 'Subhumid' (Cfa) region (Köppen 1936). Using Gentilli's *Annual Phytohydroxeric Index* (Gentilli 1972) as a measure of the bioclimatic environment, the broad-leaved plants occur in the 'semi-arid' to 'arid' regions, with phytohydroxeric indices between 2 and 5 (refer, Fig. 72). This is equivalent to the Arid Moisture region of Gentilli (1972). Narrow-leaved plants occur in the 'subhumid' bioclimatic region, with phytohydroxeric indices equal to 5 and up to 10. This is equivalent to the SemiArid Moisture region (Gentilli 1972). These annual phytohydroxeric values appear to reflect climatic zones which largely control the biomass of the vegetation. Gentilli regards the threshold value 5 as the average limit between 'subhumid' and 'semi-arid' climates. The former normally supports an open woodland, whereas the latter supports a scrub or grass formation. The threshold value 3 is the average limit between 'semi-arid' and 'arid' climates. In New South Wales, there is a close correspondence between these phytohydroxeric values, moisture regions and the

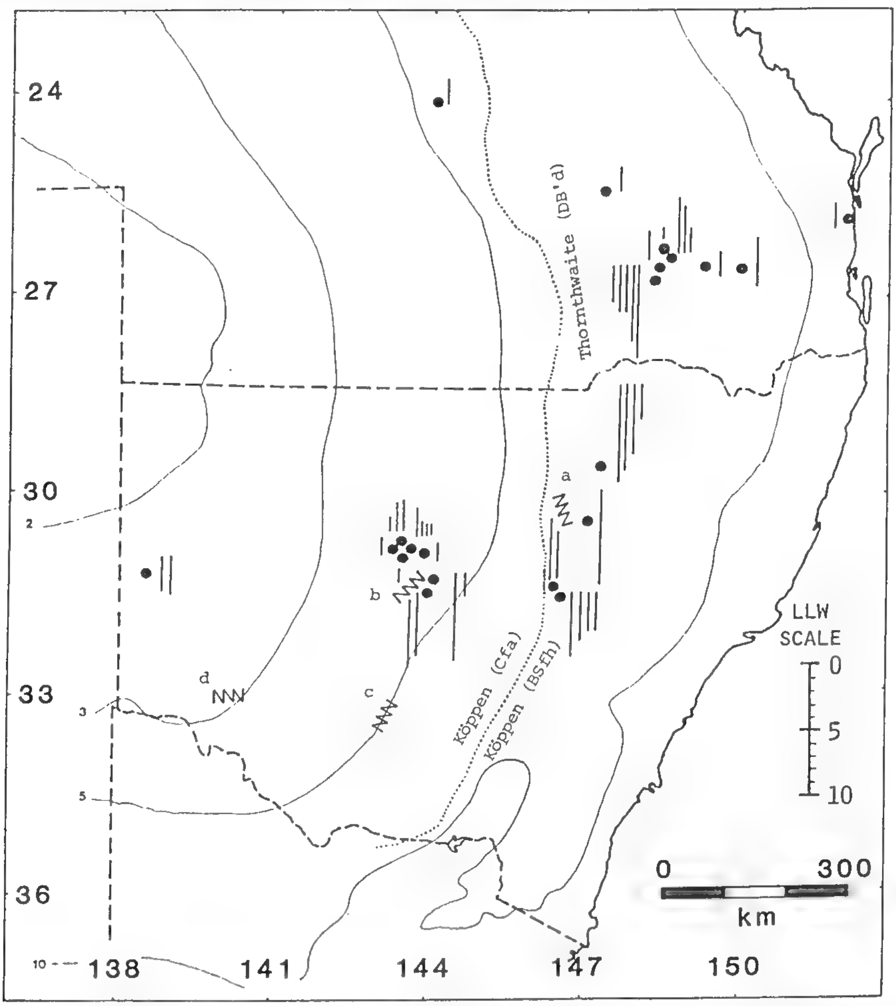


Fig. 72. Distribution map of *Prostanthera ringens*. Histograms are of lamina length to lamina width ratios (LLW). a, b, c, & d = areas of steep climatic gradients in the frequency of arid years. Gentilli's phytohydroxeric indices, Köppen's Arid/Semi-arid, and Thornthwaite's Warm semi-arid boundary (dotted line) are superimposed onto map.

type of community in which each group of plants occur. However, in the Darling Downs area of Queensland, there are a number of broad-leaved plants occurring with the narrow-leaved form (Fig. 72). The reasons for the mixture of forms in this region is not immediately obvious. However, the Darling Downs are climatically marginal, such that the transition from 'humid' to 'semi-arid' may be quite sudden and sweeping alternations are possible (Gentilli 1972).

The most consistently semi-arid areas are in the Tambo-Enniskillen (e.g. *White 12404*) and Maranoa-Balonne (e.g. *Mitchell 577 & 570*) areas.

There are a number of areas of New South Wales which have steep climatic gradients in frequency of arid years. Steep climatic gradients occur between Baradine and Coonamble (Fig. 72-a) and between Nymagee and Cobar (Fig. 72-b); other steep climatic gradients are marked on Fig. 72, c-d. In other parts of the State, there is a more gradual increase in aridity to the west and north-west. These steep gradients (particularly, Fig. 72-b) may explain the relatively sharp disjunction between the Cobar and Nymagee populations, and in general, they may act as part of the climatic boundary between these two groups.

A number of plants have been cultivated (e.g. at Burrendong Arboretum, Canberra Botanic Garden and Adelaide Botanic Gardens) and these have retained their phenotypic distinctness. Therefore, it seems likely that the two groups are also genetically distinct. Since most specimens have been cultivated from cuttings taken from the original population (only *Althofer s.n.*, 23.i.1944 cultivated from seed), we do not know the extent of the variability within each population. Detailed population studies are necessary to evaluate the ecotypic distinctness of these two groups.

Common names: Gaping mint-bush (Bailey 1883); Green-flowered mintbush (Cunningham *et al.* 1982).

Selected specimens examined (55 collections)

QUEENSLAND.—Darling Downs: *C. White 13056*, 4.x.1946, Kogan (CANB); *Everist s.n.*, -.x.1969, ENE of Dalby, on road to Kogan (NSW 128469).

NEW SOUTH WALES.—North Western Slopes: *G. Althofer s.n.*, -.ix.1968, Pilliga Forest, Narrabri (AD).—Central Western Slopes: *Willis & Althofer s.n.*, 9.x.1969, Mendooran road, in western portion of Goonoo Forest (AD 97609140, MEL 43326).—North Western Plains: *G. Cunningham 719*, 11.vii.1973, 'The Peak', Cobar (AD).—North Far Western Plains: *Kaspiew 67*, 3.x.-, Broken Hill (S).

12. **Prostanthera grylloana** F. v. Muell., Fragm. 10 (1876) 17; Briq., in Engl. & Prantl, Nat. Pflanzenfam. 4: 3a (1895) 220; Diels & Pritz, Bot. Jahrb. 35 (1904) 526, t. 59; C.A. Gardner, Enum. pl. austral. occid. (1931) 114; Blackall & Grieve, W. Austral. wildfl. 3 (1965) 594; J.S. Beard, Descr. cat. W. Austral. pl. (*s. dat.* [Oct. 1965]) 94; Althofer, Cradle of Incense (1978) 78, 80, 82.

Holotype: *Young s.n.*, 10-15.x.1875, near Ularing, Western Australia (MEL 41915).

Small erect shrub, 0.3-1.5 m high. *Branches* subterete to quadrangular, densely short-pilose from one leaf axis to next nodal region alternately. *Leaves* both clustered on short branches and arranged along main axis and branches, glabrous, glandular; *petiole* up to c. 1 mm long, often indistinct from lamina, deeply grooved on adaxial surface; *lamina* ± spathulate 3-5 (-10) x 2 (-3) mm [length to width ratio 2-3.7 (-6), distance of maximum width from base to total lamina length 0.67-0.9], recurved, coriaceous; adaxial surface deeply grooved such that both sides almost touching each other; base decurrent almost to base of petiole; margin entire, very slightly undulate; apex ± rounded; venation not visible. *Pedicel* 1-1.5 (-2) mm long, shortly tomentose; *prophylls* inserted 0.5-0.8 mm from distal end of

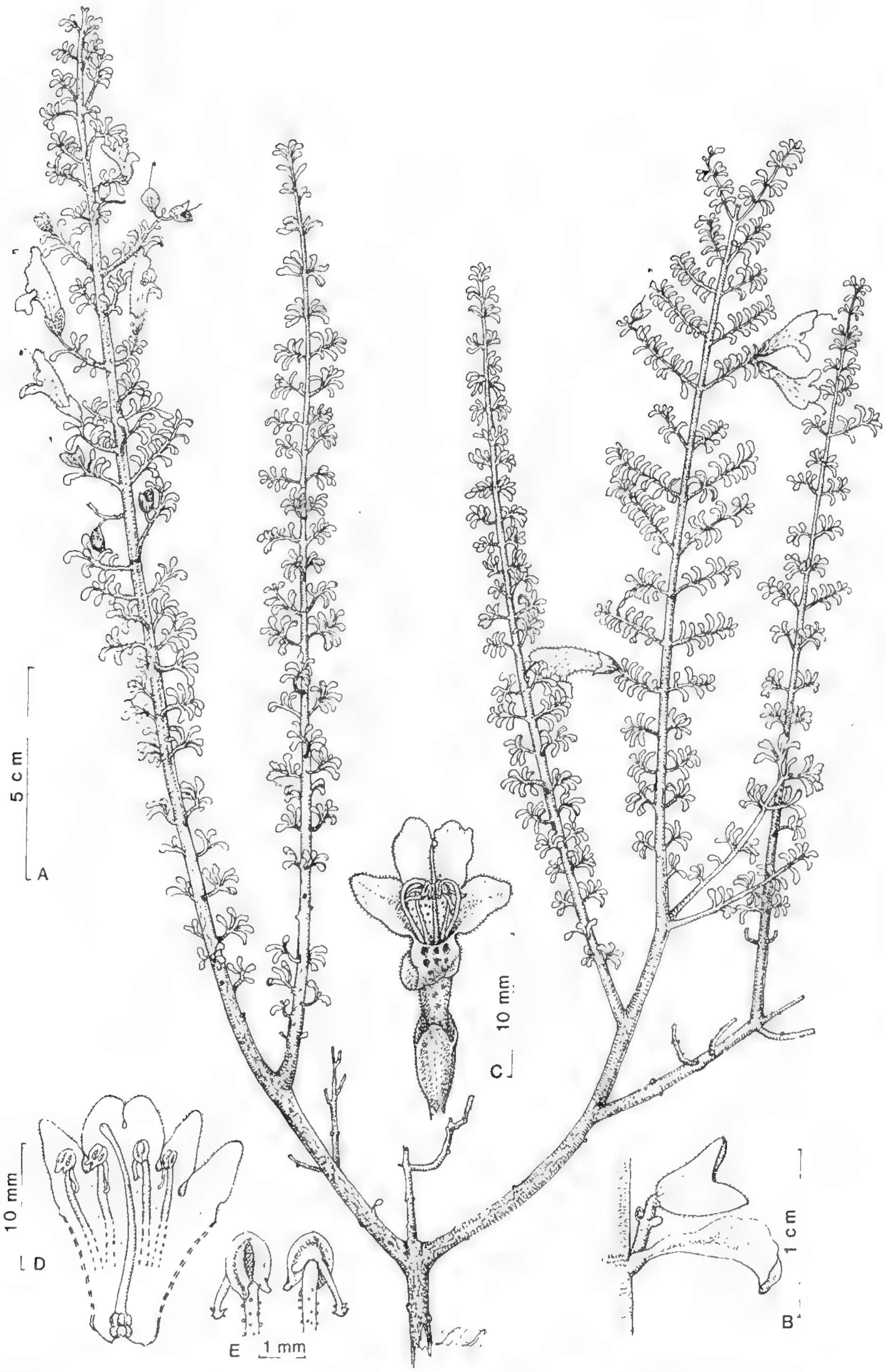


Fig. 73. *Prostanthera grylloana*.—A. twig and flowers; B. detail of leaf, pedicel, prophylls and calyx; C. flower—abaxial view; D. open corolla; E. stamens—ventral and dorsal views (all *Willis s.n.*, MEL 43160).

pedical, usually just overlapping with basal part of calyx, linear to narrow-oblong, c. 1 x 0.1 mm, soon falling off, the slightly enlarged basal part remaining (which is c. 0.2 mm long and 0.2 mm wide), minutely tomentose basally; apex subacute. *Calyx* 4-6 mm long; outer surface sparsely tomentose throughout; hairs c. 0.1 mm long; *tube* 4-4.5 mm long; inner surface glabrous; *lobes* ± triangular, c. 2 mm long, 3-4 mm wide at base; inner surface densely, minute-pilose; hairs up to c. 0.1 mm long; margin entire; apex obtuse. *Corolla* (12-) 15-20 mm long, red to dull medium mauve-pink; outer surface distally sparsely tomentose; *tube* 10-14 mm long; inner surface glabrous; *lobes* glabrous basally on inner surface, sparsely tomentose distally especially near apex and margin; *abaxial median lobe* ± triangular, c. 5 mm long, 2-3 mm wide at base; margin ± entire to slightly irregular; apex obtuse to subacute; *lateral lobes* ± triangular, c. 2.5 mm long, c. 2.5 mm wide at base, ± erect; margin entire, fimbriate; apex obtuse to subacute; *adaxial median lobe-pair* broadly oblong-ovate, 3.5-4 mm long, c. 4 mm wide at base; margin entire; apex rounded, emarginate; sinus up to 1 mm long. *Stamens* inserted c. 13 mm above base of corolla; filaments 4-5 mm long; anthers 1-1.5 mm long; base of lobes with small acumen up to 0.3 mm long; connective extended on one side to form a basal appendage 2-2.5 mm long, with a few ± triangular trichomes. *Pistil* 20-24 mm long; ovary c. 0.3 mm long; style 19-21 mm long; stigma lobes up to 0.5 mm long. *Mericarps* c. 2 mm long, distally c. 0.5 mm extended beyond base of style; seed unknown. Figs 73 & 74.

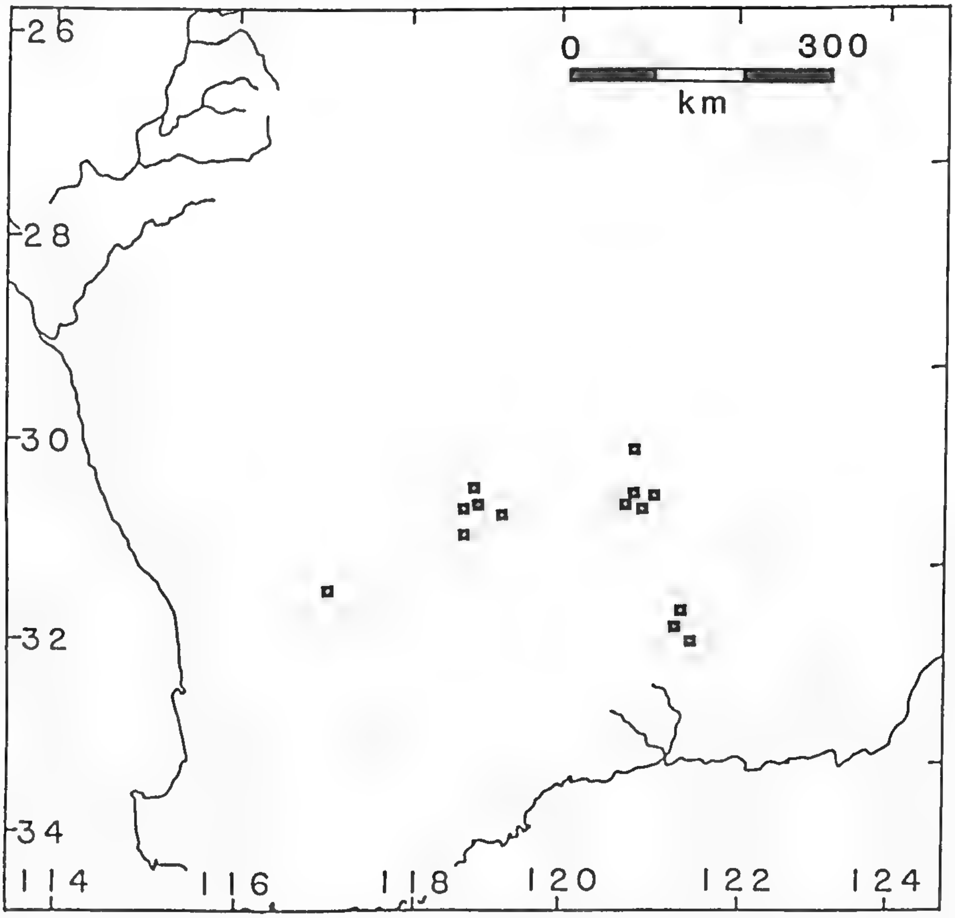


Fig. 74. Distribution map of *Prostanthera grylloana*.

Distribution

Western Australia (Eremaean: Helms, Austin, Coolgardie; South-West: Avon, Roe).

Conservation status: considered not at risk.

Ecology

This species occurs on sandy soils, frequently amongst granite outcrops on granitic loamy sands, or on compacted red clay-loams with laterites. Commonly associated with open dry sclerophyll woodland communities of *Acacia* spp., *Casuarina acutivalvis*, *C. campestris*, and *Eucalyptus* spp.

Note

P. grylloana is readily identified by its more or less conduplicate spathulate leaves. The outer surface of the calyx may appear glabrous because of the sparse indumentum and the very small hairs (*cf. Eaton s.n.*, MEL 1512004). The affinities of this species are not clear.

Selected specimens examined (60 collections)

WESTERN AUSTRALIA.—Eremaean: Helms: *Helms s.n.*, 16.ix.1891, Victoria Desert camp 54 (AD 96911024)—Austin: *Fitzgerald s.n.*, -.x.1898, Bardoc (NSW 126688, 126690, 126691); *Fraser 434/22*, -.viii.1919, between Mt Marshall and Lake Barlee (NSW); *Gardner & Blackall s.n.*, -.ix.1927, Comet Vale (PERTH); *Jutson 277*, -.viii.1917, Comet Vale (NSW).—Coolgardie: *Alpin 1886*, 9.ix.1962, 23 miles S of Coolgardie (PERTH); *Blackall 950*, 11.x.1931, near Bullabulling (PERTH); *Chinnock 3114*, 19.ix.1976, 40.2 km NNW of Bullfinch (AD); *Davies 211*, 2.v.1963, Spargoville (PERTH); *George 4245*, 22.ix.1962, 20 miles SW of Coolgardie (PERTH); *Helms s.n.*, 12.xi.1891, Gnarlbine (AD 96911025, MEL 41914, NSW 126692); *Phillips s.n.* (*CBG 26145*), 6.ix.1968, 22 miles from Coolgardie towards Norseman (AD 96920341); *Short 923*, 12.xi.1979, Wargangering Rock (AD); *Wilson 3461*, 22.ix.1964, c. 1 km E of Walgoolan (AD). South-West: Avon: *Blackall 862*, 3.x.1931, near Campion (PERTH); *Chinnock 3127*, 20.ix.1976, 9.8 km S of Warralakin (AD); *Chinnock 5058*, 6.xii.1980, 3 km NNE of Westonia (AD); *Wilcox s.n.*, -.iv.1954, Warralakin Rock (PERTH); *Merrall s.n.*, *anno* 1888, E sources of Swan River (MEL 43877).—Roe: *Brockway 8*, -.x.1944, Grasspatch (PERTH); *Phillips s.n.* (*CBG 19296*), 6.xi.1962, 1 miles N of Salmon Gums (NSW); *Wrigley s.n.* (*CBG 33671*), 12.xi.1968, 99 miles N of Esperance (AD, CBG).

13. **Prostanthera monticola** Conn, *sp. nov.*

P. walteri auct. non F. v. Muell. (1870): C. Moore, Handb. fl. New S. Wales (1893) 352; Dixon, Pl. New S. Wales (1906) 232; Harris, Alpine pl. Austral. (1970) 142, *p.p.*; Galbraith, Wildfl. SE Austral. (1977) 326, *p.p.*

'*Prostanthera* sp. aff. *P. walteri*': Althofer, Cradle of Incense (1978) 116.

Species nova Sectionis Klanderiae. *Frutices* 0.3-2 m. alti. *Rami* et ramuli subteretes usque subquadrangulares, tomentosi, pilis appressis, 0.3-0.4 mm. longis, internodiis iuvenibus saepe octo-porcatis. *Petiolus foliorum* (1.5-) 2-5 mm. longus, tomentosus usque glabrescens; *lamina* angusta, ovata usque elliptica, 15-50 mm. longa, 5-13 mm. lata, pagina abaxiali glabra, pagina adaxiali sparsim tomentosa vel glabra, basi cuneata usque subacuta, margine integro, recurvo, apice obtuso. *Pedicellus florum* 2-3 mm. longus, dense tomentosus, pilis circa 0.1 mm. longis, *prophyllis* ad basim calycis affixis, 10-18 mm. longis. *Calyx* 10-15 mm. longus, extra ad basim sparsim tomentosus usque glabrescens, alibi glaber; *tubus* 5-6 mm. longus; *lobi* ovati usque deltoidei, 6-9 mm. longi, 4-5 mm. lati, intra tomentosi, pilis circa 0.1 mm. longis, margine integro, apice obtuso usque angusto-acuto. *Corolla* 30-35 mm. longa, veneta; *tubus* 18-20 mm. longus, extra in partibus distalibus sparsim tomentosus; *lobi* intra sparsim tomentosi vel glabri, *abaxiali-mediano* plus minusve suborbiculari, 8-10 mm. longo, circa 10 mm. lato, margine irregulari, apice plus minusve rotundato, emarginato, sinu circa 1 mm. longo, *lateralibus* deltoideis, 7-8 mm. longis, circa 5 mm. latis, margine integro, apice subacuto usque acuto, *adaxiali-mediano* plus minusve ovato, leviter trilobo, circa 10 mm. longo, circa 12 mm. lato, margine integro, apice plus minusve obtuso, emarginato, sinu circa 1 mm. longo. *Stamina* circa 11 mm. e basi corollae affixa; filamenta 10-13 mm. longa; antherae 1.5-2 mm. longae, connectivo per trichomata deltoidea ultra loculis producto. *Pistillum* circa 25 mm. longum; ovarium circa 0.5 mm. longum; stylus 18-22 mm. longus; lobis stigmatis circa 1 mm. longis. *Fructus* coccis 1.5-2 mm. longis.

Holotypus: *Conn (& Campbell) 731*, 4.ii.1980, Crystal Brook Falls, Mt Buffalo, Eastern Highlands, Victoria (MEL; iso in AD, CANB).

Sprawling, open shrub, 0.3-2 m high. *Branches* subterete to subquadrangular, often with approximately 8 ridges distally, red, hairy, densely so on upper internodes and nodes; hairs appressed, 0.3-0.4 mm long, white. *Leaves* arranged along main axis and branches, not clustered; *petiole* (1.5-) 2-5 mm long; upper surface grooved, reddish when young, tomentose basally, sparsely tomentose to glabrescent distally; hairs c. 0.1 mm long, white; *lamina* narrow, ovate to elliptic, 15-50 x 5-13 mm [lamina length to width ratio 3-6.7; ratio of distance maximum width from lamina base to total lamina length 0.3-0.5], coriaceous; abaxial surface glabrous; adaxial surface sparsely tomentose (hairs c. 0.2 mm long, white) or glabrous; base cuneate to subacute; margin entire, recurved; apex obtuse; venation faint to indistinct; midrib raised on abaxial surface (usually with a few scattered hairs), sunken on adaxial surface (usually with red wart-like glands). *Pedicel* 2-3 mm long, flattened, densely tomentose; hairs c. 0.1 mm long, white; *prophylls* inserted at distal end of pedicel and so overlapping calyx, ± linear, 10-18 mm long, equal to length of calyx or often extended beyond calyx, usually recurved, concave; abaxial surface sparsely minute-tomentose basally, glabrous distally; adaxial surface glabrous; apex ± obtuse. *Calyx* 10-15 mm long, green; outer surface sparsely tomentose to glabrescent basally, glabrous distally; *tube* 5-6 mm long; inner surface with scattered pedicellate glandular trichomes; *lobes* ovate to triangular, 6-9 mm long, 4-5 mm wide at base; inner surface minutely hairy; hairs c. 0.1 mm long, glabrous at apex; margin entire (not ciliate); apex obtuse to tapering-acute; apex of abaxial lobe often more obtuse than adaxial lobe. *Corolla* 30-35 mm long, pale blue-green to grey-green, with dark purple-blue veins; *tube* 18-20 mm long, sparsely tomentose distally, especially medially and towards margin; *lobes* sparsely tomentose on outer surface; hairs c. 0.2 mm long; *abaxial median lobe* ± semi-orbicular, 8-10 mm long, c. 10 mm wide, sparsely pilose-tomentose medially; margin irregular; apex ± rounded, emarginate; sinus c. 1 mm long; *lateral lobes* triangular, 7-8 mm long, c. 5 mm wide at base; inner surface sparsely pilose-tomentose; margin entire; apex subacute to acute; *adaxial median lobe-pair* ± ovate, faintly 3-lobed, c. 10 mm long, c. 12 mm wide at base; inner surface glabrous, except often sparsely pilose-tomentose near margin between faint lobes; margin entire; apex ± obtuse, emarginate; sinus c. 1 mm long. *Stamens* inserted c. 11 mm above base of corolla; filaments 10-13 mm long; anthers 1.5-2 mm long; base of lobes with small acumen; connective slightly extended basally, with deltoid trichomes present, trichomes c. 0.2 mm long. *Pistil* c. 25 mm long; ovary up to c. 3 mm long, diameter at base c. 1 mm, lobes small; style 18-22 mm long; stigma lobes c. 1 mm long. *Mericarps* 1.5-2 mm long, distally extended c. 1 mm beyond base of style. Figs 75 & 76.

Distribution

New South Wales (Southern Tablelands) and Victoria (Eastern Highlands).

Conservation status

Although the distribution of this species is restricted, it is not considered to be endangered or vulnerable—Risk code = 3R,C ([Conn, in] Leigh *et. al*, 1981, pp. 49 & 104 [as *P. walteri*] assigns a risk code value of 2R to this species).

Ecology

Commonly associated with *Eucalyptus delegatensis*, *E. pauciflora* (*E. niphophila*), *E. perriniana*, *E. stellulata* or *E. viminalis* woodlands, commonly growing with *Boronia algida*, *Bossiaea foliosa* and/or *Oxylobium alpestre*, on deeply weathered granitic soils amongst granitic rocks. Altitude 530-1833 m.

Note

This species is very closely related to *P. walteri*. *P. monticola* has longer prophylls

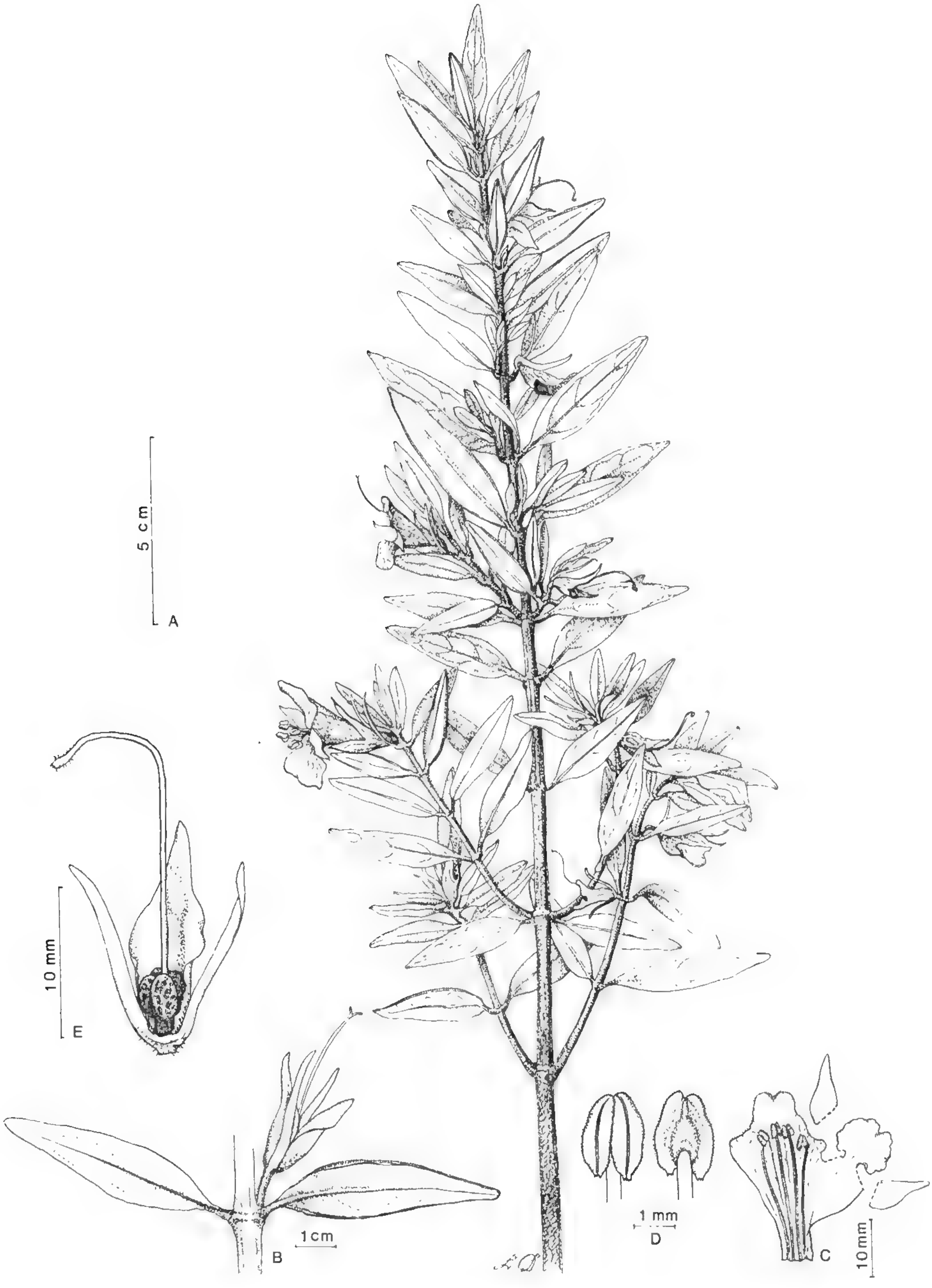


Fig. 75. *Prostanthera monticola*.—A. twig and flowers; B. detail of leaves, pedicel, prophylls, calyx and style; C. open corolla; D. stamens—ventral and dorsal views; E. part of calyx removed to reveal mericarps and style (all *Carrick 3125*).

(10-18 mm long *cf.* 4-6.5 mm long in *P. walteri*) and the inner surface of the calyx-lobes are hairy (glabrous in *P. walteri*). Frequently, *P. walteri* has longer hairs on the vegetative parts than does *P. monticola* and the density of hairs is usually greater in the former species.

Both species appear to occupy a unique 'position' within sect. *Klanderia.* Both have large petiolate leaves (petiole 1.5-8 mm long; lamina 10-50 x 5-17 mm) which are more typical of sect. *Prostanthera.* The preliminary results from the volatile leaf oil analysis (p. 284) suggest that both species have very low amounts of terpenoids, whereas all other species of this section (which have been sampled) are relatively rich in terpenoids. Furthermore, *P. monticola* and *P. walteri* are the only species of sect. *Klanderia* which occur above the snow-line.

Selected specimens examined (49 collections)

NEW SOUTH WALES.—Southern Tablelands: *Ashby 2086* (collected by Stead), 16.i.1967, Schlink Pass road, near Geehi River crossing, Mt Kosciusko National Park (AD); *Briggs 2542*, 10.ii.1969, ½ mile NW of Round Mt (AD); *Costin s.n.*, 15.ix.1948, Big Badja Mountain (NSW 126710); *Gittins 415*, -.i.1962, Dickie Cooper Creek (NSW).

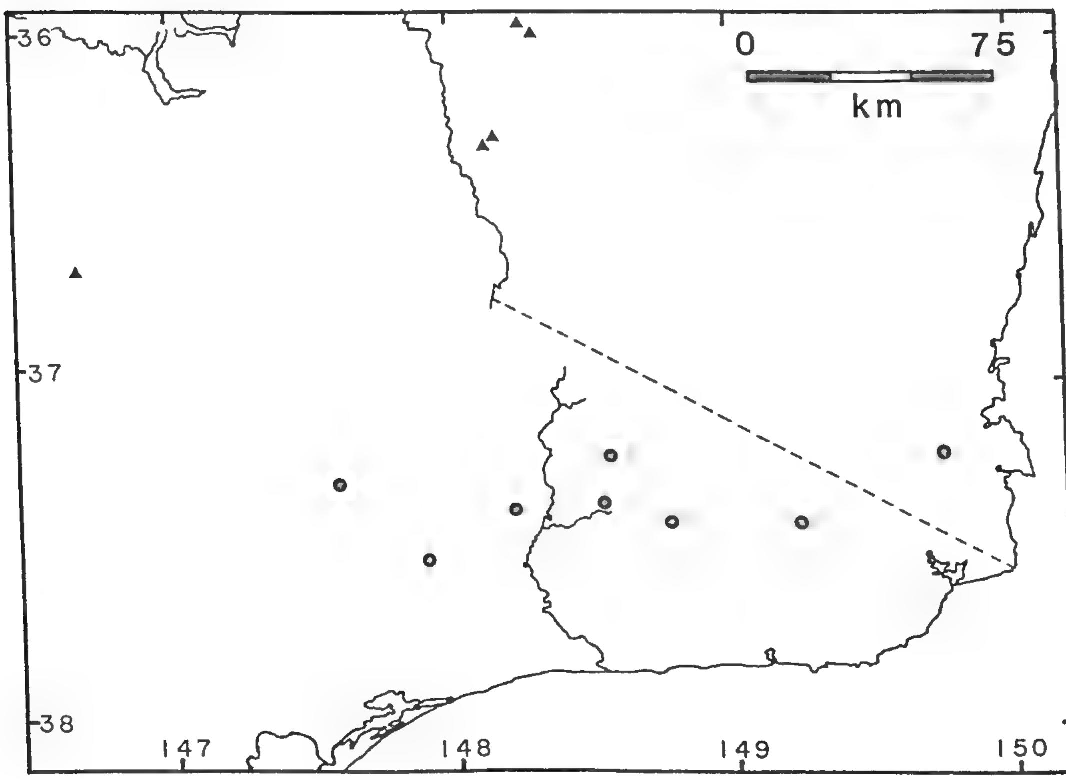


Fig. 76. Distribution map of *Prostanthera monticola* (▲) and *Prostanthera walteri* (•).

VICTORIA.—*Beauglehole 17096*, -.i.1950, lookout above where Crystal Brook drops down, Mt Buffalo (AD); *Beauglehole 41681*, 28.iii.1973, Mt Buffalo National Park, below Chalet (AD); *Briggs s.n.*, 23.xii.1952, near Chalet, Mt Buffalo National Park (NE); *Cambage 3686*, 19.i.1913, Mt Buffalo (NSW, SYD); *Carlisle s.n.*, -.iii.1893, Buffalo ranges (MEL 41923); *Carrick 3011*, 6.xii.1971, Mt Buffalo (AD); *Conn & Campbell 731-735*, 4.ii.1980, Crystal Brook Falls, Mt Buffalo (AD); *Dunlop s.n.*, 14.i.1969, Creek below dam wall of Lake Catani, Mt Buffalo (CBG); *French s.n.*, -.xii.1904, Buffalo ranges (MEL 41920, MEL 91921); *Gauba 3305*, 10.ii.1955, Mt Buffalo (AD); *Gray & Totterdell 5826*, 17.xii.1965, Mt Buffalo (CANB, NSW); *Hill 1263*, 31.xii.1963, Mt Buffalo plateau (AD); *Kinnear s.n.*, -.i.1953, Mt Buffalo (AD); *Muir 653*, 2.i.1959, near Lake Catani, Mt Buffalo (AD, MEL, NSW); *Nettie s.n.*, -.i.1923, Buffalo Mts (NSW 126711); *Short 1383*, 27.i.1982, c. 200 m down from summit of Mt McLeod (MEL); *Walter s.n.*, -.xi.1903, Buffalo Mts (MEL 41922); *Weindorfer s.n.*, 28.xii.1902, Buffalo Mts (NSW); *Weindorfer s.n.*, -.xii.1903, Buffalo Mts (NSW 126714); *Williamson s.n.*, 30.xii.1918, Buffalo Mts (NSW 126712); *Willis s.n.*, 18.ii.1963, Mt Buffalo National Park (MEL 43787).

14. **Prostanthera walteri** F. v. Muell., Fragm. 7 (1870) 108; Key Vict. pl. 2 (1885) 42; *op. cit.* 1 (1887) 386; Guilfoyle, Austral. pl. (1911) 306; Pescott, Nat. fl. Victoria (*s. dat.* [1914]) 99; Ewart, Fl. Victoria (1930) 982; Harris, Alpine pl. Austral. (1970) 142, p.p.; Galbraith, Wildfl. SE. Austral. (1977) 326, p.p.; Althofer, Cradle of Incense (1978) 116, 119, 121, 122.

Holotype: *C. Walter s.n.*, *anno* 1870, 'Mt Ellery, Gippsland', Victoria (MEL 41927).

Sprawling shrub, 1-2 m high. *Branches* forming a tough wiry entanglement, ± terete, densely ± patent-pilose to appressed-tomentose; hairs (0.5-) 0.8-1 (-1.5) mm long and 0.1-0.3 mm long, respectively, strongly curved when indumentum tomentose, glandular. *Leaves* arranged along main axis and branches, not clustered; *petiole* 2-5 (-8) mm long; adaxial surface grooved, hairy, as for branches; *lamina* ovate to slightly rhombic, (10-) 18-26 (-38) x 5-15 (-17) mm [lamina length to width ratio 1.4-2.5; ratio of distance maximum width from lamina base to total lamina length 0.2-0.45]; abaxial surface pilose to tomentose, with hairs 0.5-0.8 mm long and 0.3-0.4 mm long respectively, strongly curved when indumentum tomentose; adaxial surface appearing glabrous, however sparsely minute-tomentose, especially on midrib, with hairs up to c. 0.1 mm long; base obtuse, subacute to cuneate; margin entire, recurved; apex obtuse; venation faint; midrib raised on abaxial surface, slightly sunken on adaxial surface; veins mostly indistrinct, slightly raised on abaxial surface, very slightly sunken adaxially. *Pedicel* 3-6 mm long, hairy, as for branches; *prophylls* inserted near distal end of pedicel (within 1 mm of calyx) and so overlapping calyx, linear-obovate, 4-6.5 mm long, usually recurved, concave; abaxial surface sparsely hairy to glabrescent; adaxial surface glabrous; margin recurved; apex obtuse. *Calyx* 10-12 mm long, striate; outer surface pilose throughout or ± pilose at base, becoming glabrous or sparsely tomentose distally, or glabrous throughout; inner surface glabrous; *tube* 4-5 mm long; *lobes* broadly ovate, 3-6 (-7) mm long, 5-7 mm wide at base; margin entire; apex obtuse to rounded. *Corolla* (15-) 18-26 mm long, blue-green, rarely green-yellow, prominently purple-veined; *tube* 12-16 mm long, diameter at mouth 4-7 mm; outer surface sparsely tomentose distally; hairs up to 0.2 mm long; inner surface glabrous; *lobes* sparsely short-tomentose on outer surface, becoming denser near margin; inner surface glabrous; *abaxial median lobes* ± spathulate, 5-10 x 3-9.5 mm, c. 1.5 mm wide at base; apex rounded, irregular, slightly lobed; *lateral lobes* narrow oblong-ovate, (4-) 5-7 (-10) mm long, 1-1.5 mm wide at base; apex obtuse; *adaxial median lobe-pair* broadly ovate, 5-10 mm long, 6-10 mm wide at base; apex obtuse, slightly emarginate; sinus c. 0.5 mm long. *Stamens* inserted c. 10 mm above base of corolla; filaments c. 6 mm long, often with broad-deltoid glandular trichomes; anthers 1.5-2 mm long; base of lobes with small acumen; connective often extended on one side to form a basal appendage c. 0.4 mm long, with narrow-deltoid trichomes usually present, or appendage absent. *Pistil* 20-27 mm long; ovary 1-1.5 mm long, diameter at base c. 1 mm, lobes small; style 18-23 mm long; stigma lobes 0.5-1 mm long. *Mericarps* c. 2 mm long, distally extended c. 0.6 mm beyond base of style. Figs 76 & 77.

Distribution

New South Wales (South Coast) and Victoria (Eastern Highlands—East Gippsland).

Conservation status

Although the distribution of this species is restricted, it is not considered to be endangered or vulnerable—Risk code = 3R ([Conn, in] Leigh *et al.*, 1981, pp. 49 & 110 assigns a risk code value of 2R to this species).

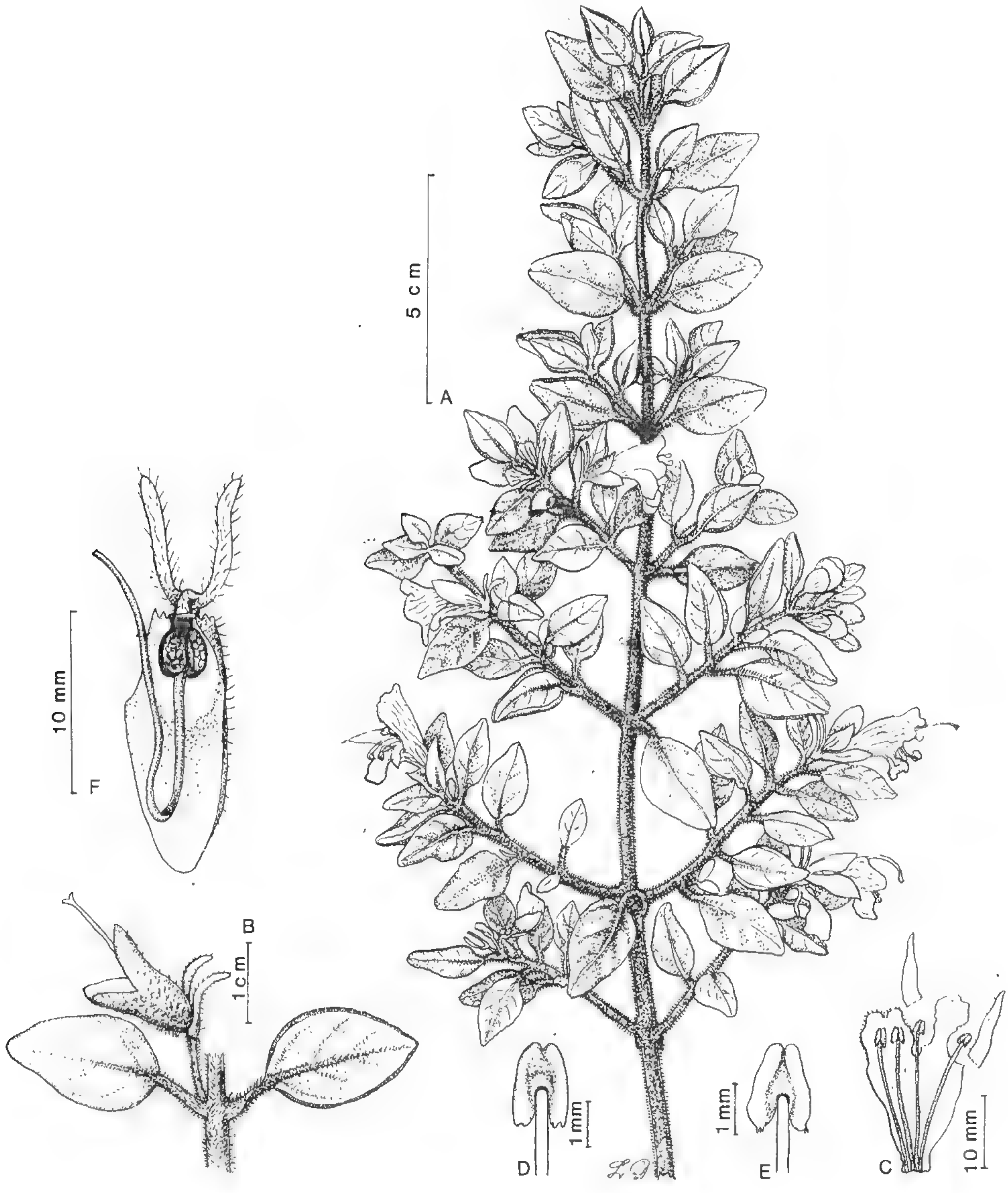


Fig. 77. *Prostanthera walteri.*—A. twig and flowers; B. detail of leaves, pedicel, prophylls, calyx and style; C. open corolla; D. stamens—dorsal view; E. stamens—ventral view; F. part of calyx removed to reveal mericarps and style (all *Carrick 3033*).

Ecology

Commonly occurring in granitic soils, associated with *Eucalyptus imlayensis, E. obliqua, E. regnans, E. sieberi, E. viminalis, Blechnum wattsii, Dicksonia antarctica, Eriostemon virgatus, Oxylobium ellipticum* and *Pultenaea juniperina*. Altitude (850-) 1030-1400 m.

Notes

This species is very closely related to *P. monticola. P. walteri* is readily distinguishable from *P. monticola* by its glabrous inner surface of the calyx (hairy lobes in *P. monticola*) and by its shorter prophylls. For further details refer 'Notes' for *P. monticola.*

Common names

Blotchy mint-bush (Ewart 1930, Willis 1973): Monkey mint-bush (Willis 1973).

Selected specimens examined (40 collections)

NEW SOUTH WALES.—South Coast: *Telford 7256*, 5.xii.1978, Mt Imlay (CBG).

VICTORIA.—Eastern Highlands (East Gippsland): *Beauglehole 34062*, 20.ix.1970, Mt Kaye (AD); *Beauglehole 35729*, 3.i.1971, Monkey Top Track, S of Bowen Range (AD); *Beauglehole 37084*, 27.ii.1971, W of Mt Baldhead, Bruthen road (AD); *Beauglehole 37111*, 28.ii.1971, Mt Elizabeth II, north side (AD); *Beauglehole 37726*, 2.iv.1971, Yalmy road, Yalmy river area (AD); *Carrick 3033, 3036*, 8.xii.1971, Summit of Mt Ellery (AD); *Conn 709-714*, 1.xii.1979, Mt Ellery (AD); *Conn 724-726*, 2.xii.1979, Mt Elizabeth No. 2 (AD); *Czornij 441*, 8.xii.1971, Summit of Mt Ellery (AD); *French s.n.*, -.i.1889, Summit of Mt Ellery (MEL 41918); *French s.n., s. dat.* E. Gippsland (P); *Hodge s.n.*, 13.ii.1948, main top E of "W-Tree" (MEL 41929); *Hodge s.n.*, 23.iv.1957, cultivated at W-Tree (MEL 41925); *Howitt 15, anno* 1884, Gippsland (MEL 41926); *Purdie 289, anno* 1894, Mt Ellery (MEL 41919); *Wakefield s.n.*, 20.xi.1947, Summit of Mt Kaye, upper Cann River valley (MEL 43784); *Walter s.n., anno* 1870, Mt Ellery (MEL 41927) (TYPE); *Walter s.n., anno* 1871, Gippsland (MEL 41917); *Willis s.n.*, 17.xi.1968, Yalmy river track between Buchan & Goongerah (AD 97609146, MEL 43786); *Willis & Wakefield s.n.*, 16.x.1948, Mt Kaye (MEL 43785); *Willis & Wakefield s.n.*, 29.xii.1951, Mt Ellery (AD 97609145, MEL 43782, MEL 43783).

15. **Prostanthera porcata** Conn, *sp. nov.*

Species nova Sectionis Klanderiae. *Frutices* 1.5-2 m. alti. *Rami* et ramuli glabri, dense glandiferi, plus minusve quadrangulares, quadriporcati; cristae persistentes et petiolis adnatis. *Petiolus foliorum* (2-) 4-8 mm. longus, parum canaliculatus, canali piloso; *lamina* complanata, parum canaliculata basaliter, plus minusve elliptica usque anguste elliptica, (18-) 24-36 mm. longa, (7-) 9-14 mm. lata, basi attenuata, margine integro vel plus minusve minute lobato. *Pedicellus florum* 4-5 mm. longus, glaber, glandifer, *prophyllis* ad basim calycis affixis, plus minusve linearibus, 2.8-5.6 mm. longis, 0.3-0.4 (-0.7) mm. latis. *Calyx* 12-15.5 mm. longus, glaber, glandifer; *tubus* 8-9 mm. longus; *lobi* latissime deltoidei, (4-) 5-7 mm. longi, circa 4-5 mm. lati, margine integro, apice obtuso. *Corolla* (21-) 23-27 (-31) mm. longa, rosea vel cremea basaliter et subrosea distaliter; *tubus* 15-22 mm. longus; *margines loborum* parum fimbriati, *abaxiali-mediano* oblongo usque subspathulato, 3-4.5 mm. longo, circa 3-3.5 mm. latis, margine integro, apice plus minusve truncato et plus minusve irregulari, *lateralibus* ovato-deltoideis, 2-3.5 mm. longis, 2-3 mm. latis, margine integro, apice obtuso, *adaxiali-mediano* plus minusve depresse ovato, 5-6 mm. longo, 9-10.5 mm. lato, margine integro vel saepe parum irregulari, retuso, sinu usque ad 0.5 mm. longo. *Stamina* circa 14-15 mm. e basi corollae affixa; filamenta circa 8-9 mm. longa; antherae 1.3-2 mm. longae, appendice 2-3 mm. longa. *Pistillum* 26-32 mm. longum; ovarium 0.5-1.3 mm. longum; stylus circa 29-32 mm. longus; lobis stigmatis circa 0.2 mm. longis. *Fructus* immaturi.

Holotypus: *Gilmour s.n.*, 22.vi.1982, 4 km SE. of Mt Budawang, Budawang National Park, New South Wales (MEL 644089; *iso* in AD, CANB 8203466, CBG, K, NSW).

Erect shrub, 1.5-2 m high. *Branches* glabrous, densely glandular [200-350 glands/mm^2]; glands hemispherical, branches ± quadrangular with 4 ridges; ridges persistent (at least distally), adnate to petiole, extending from base of petiole to the next more basal internode, c. 0.3 mm high, crest rounded. *Leaves* arranged along the branches; *petiole* (2-) 4-8 mm long, slightly channelled with abaxial surface glabrous; adaxial surface hairy along midrib with hairs 0.1-0.3 mm long, glandular; *lamina* flattened, slightly channelled basally ± elliptic to narrowly elliptic, (18-) 24-36 x (7-) 9-14 mm [lamina length to width ratio

(2-) 2.2-3.7; ratio of distance of maximum width from lamina base to total lamina length 0.5-0.7]; base attenuate; margin entire or minutely notched to minutely lobed (sinus less than 1 mm long); apex obtuse to slightly rounded; venation indistinct; midrib raised on abaxial surface and slightly sunken on basal portion of adaxial surface. *Pedicel* 4-5 mm long, glabrous, glandular; *prophylls* inserted up to c. 1 mm from base of calyx, hence overlapping basal part of calyx, ± linear, 2.8-5.6 x 0.3-0.4 (-0.7) mm [length to width ratio 9.3-14.4], ± flattened, glabrous, glandular; margin entire; apex subacute to obtuse. *Calyx* 12-15.5 mm long, glabrous, glandular (density c. 225 glands/mm^2); *tube* 8-9 mm long, 4-5 mm wide at mouth; *lobes* very broadly triangular, (4-) 5-7 mm long, c. 4-5 mm wide at base; margin entire; apex obtuse. *Corolla* (21-) 23-27 (-31) mm long; cream basally, shading to pink on lobes, or deep pink throughout; *tube* 15-22 mm long; *lobes* with margin sparsely fimbriate; hairs c. 0.1 mm long; *abaxial median lobe* oblong to subspathulate, 3-4.5 mm long, c. 3-3.5 mm wide at base; margin entire; apex ± truncate, ± irregular; *lateral lobes* ovate-triangular, 2-3.5 mm long, 2-3 mm wide at base; margin entire;

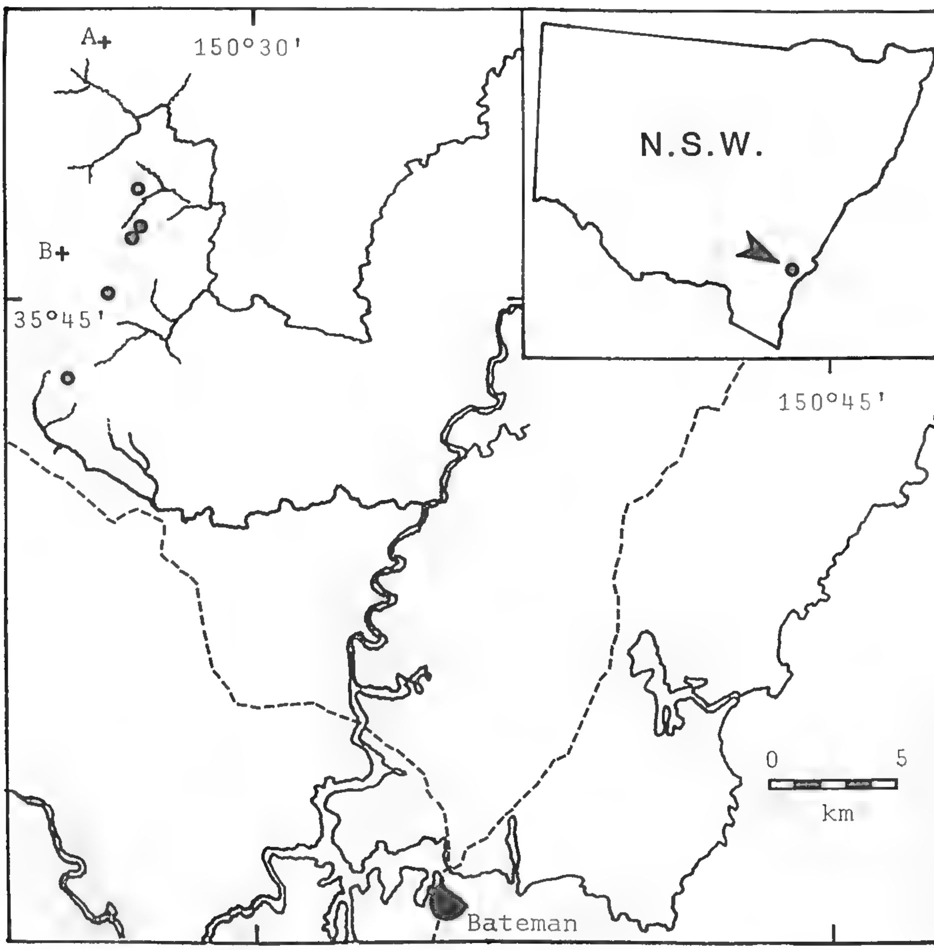


Fig. 78. Distribution map of *Prostanthera porcata*. A = Mt Currockbilly; B = Mt Budawang; major roads in discontinuous lines. Locality of Budawang Range given in insert map.

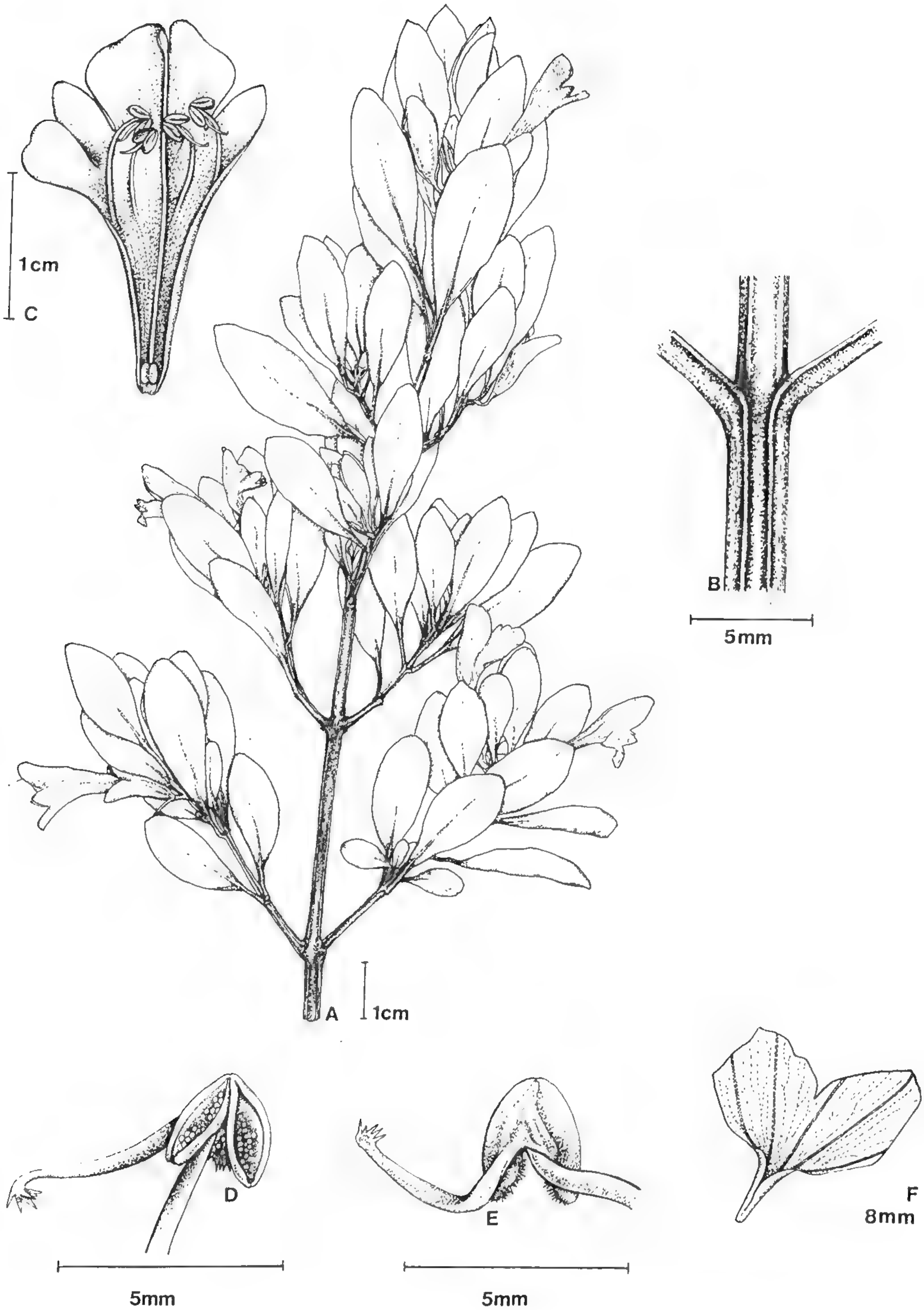


Fig. 79. *Prostanthera porcata*.—A. twig and flowers; B. detail of branch and leaf bases; C. open flowers; D. ventral view of stamens; E. dorsal view of stamen with filament displaced sideways (all *Gilmour CBG 8203466*); F. open calyx showing principal veins (*Telford 8826*).

apex obtuse; adaxial median lobe-pair ± depressed ovate, 5-6 mm long, 9-10.5 mm wide; margin entire often slightly irregular; apex rounded, retuse with sinus up to 0.5 mm long. *Stamens* inserted c. 14-15 mm above base of corolla; filaments c. 8-9 mm long; anthers 1.3-2 mm long; lobes with a minute acumen up to 0.1 mm long; one side of connective basally extended to form an appendage 2-3 mm long; appendage with linear-triangular trichomes distally (trichomes 0.1-0.2 mm long). *Pistil* 26-32 mm long; ovary 0.5-1.3 mm long, diameter less than 1 mm at base, lobes small, c. 0.2-0.5 mm long; style c. 29-32 mm long; stigma lobes c. 0.2 mm long. *Mericarps* immature. Figs 78 & 79.

Distribution

New South Wales (South Coast).

Conservation status

The conservation status of this species is not known. However it may be endangered or vulnerable since its distribution is very localized—Risk code = 2K,C.

Ecology

Occurs in open *Eucalyptus agglomerata-E. sieberi* forest, with *Casuarina littoralis* and *Eriostemon myoporoides*, on steep rocky slopes with skeletal sandy loam soils on metamorphosed sandstone and conglomerates. Altitudes 450-500 m.

Notes

This species is characterized by the 4-ridged quadrangular branches. The relatively large leaves and glabrous inner surface of the calyx suggest affinities with *P. walteri*.

Specimens examined

NEW SOUTH WALES.—South Coast (Budawang National Park): *Gilmour s.n.*, 30.v.1982, Dingo Road, 4 km SSE. of Mt Budawang (CBG 8213090); *Gilmour s.n.*, 13.vi.1982, South Boundary Road, 4 km SE. of Mt Budawang (CBG 8213089); *Gilmour s.n.*, 22.vi.1982, *l.c.* (AD, CANB, CBG 8203466, K, MEL 644089, NSW); *Telford (& Lockwood) 8825, 8826*, 19.viii.1982, 4 km SE. of Mt Budawang (CBG); (Deva National Park): *Gilmour 4318*, 15.ii.1984, c. 2 km N. of Coondella trig. (CBG).

Nomen sedis incertae

Prostanthera caleyi Benth., Labiat. gen. spec. (1834) 454; in DC., Prodr. 12 (1848) 562.

Type: *Caley s.n. in herb. Lambert, s. dat.*, 'Hab. in Nova Hollandia' (?BM, *n.v.*).

Notes

The status of this species is unknown and I have not located collections which are referable to the protologue (Bentham 1834). Bentham (1870) also regarded the status of this species as uncertain. He was unable to re-examine the material 'owing to the dispersion of the Lambertian herbarium' (Bentham 1870; also refer Stafleu & Cowan 1979). Since most of Caley's collections are held at the British Museum (BM) (Stafleu & Cowan 1976), it seems likely that the type of this taxon, may be held there. Unfortunately, collections on loan from the British Museum were returned before this taxon was considered.

Bentham (1834) regarded *P. caleyi* as closely related to *P. aspalathoides*. However, the long anther appendage ('*antherarum calcare longiore loculum subaequante*') and the ovate-elliptic leaves makes it less likely to be closely related to this species. Bentham (1870) tentatively suggested that the relationship was possibly more likely to be with *P. chlorantha*.

However, Caley did not visit South Australia (Currey 1966) and so, could not have collected *P. chlorantha* or any species closely related to it. Since he only collected from the eastern States (as far west as Westernport Bay in Victoria, and south to Tasmania), this taxon is probably from section *Prostanthera.*

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References

Adams, R.P. (1969). "Chemosystematic and numerical studies in natural populations of *Juniperus*". (Unpubl. Ph. D. dissertation. Univ. of Texas, Austin).

Adams, R.P. (1970a). Seasonal variation of terpenoid constituents in natural populations of *Juniperus pinchotii* Sudw. *Phytochemistry* 9: 397-402.

Adams, R.P. (1970b). Chemosystematic and numerical studies of natural populations of *Juniperus ashei* Buch. *Taxon* 19: 728-751.

Adams, R.P. (1970c). Contour mapping and differential systematics of geographic variation. *Syst. Zool.* 19: 385-390.

Adams, R.P. (1972a). Chemosystematic and numerical studies of natural populations of *Juniperus pinchotii* Sudw. *Taxon* 21: 407-427.

Adams, R.P. (1972b). Numerical analysis of some common errors in chemosystematics. *Brittonia* 24: 9-21.

Adams, R.P. (1974). Computer graphic plotting and mapping of data in systematics. *Taxon* 23: 53-70.

Adams, R.P. (1975). Statistical character weighting and similarity stability. *Brittonia* 27: 305-316.

Adams, R.P. (1979). Diurnal variation in the terpenoids of *Juniperus scopulorum* (Cupressaceae)—summer versus winter. *Amer. J. Bot.* 66: 986-988.

Adams, R.P. & A. Hagerman (1976). A comparison of the volatile oils of mature versus young leaves of *Juniperus scopulorum*: chemosystematic significance. *Biochem. Syst. Ecol.* 4: 75-79.

Adams, R.P. & A. Hagerman (1977). Diurnal variation in the volatile terpenoids of *Juniperus scopulorum* (Cupressaceae). *Amer. J. Bot.* 64: 278-285.

Adams, R.P. & B.L. Turner (1970). Chemosystematic and numerical studies of natural populations of *Juniperus ashei* Buch. *Taxon* 19: 728-751.

Althofer, G.W. (1978). "Cradle of incense. The story of Australian *Prostanthera*". (*Soc. Growing Austral. Plants*: Sydney).

Anderson, R.H. (1961). Introduction. *Contr. New S. Wales Natl. Herb.* New South Wales, Nos 1-18: 1-15.

Anon. (1971). "Your Australian garden. No. 2. Mintbushes and their relatives". (David G. Stead Mem. Wildlife Res. Foundation Austral.: Sydney).

Anon. (1977). Canberra botanic gardens—Growing native plants. 7: 157-159.

Armstrong, J.A. (1979). Biotic pollination mechanisms in the Australian flora—a review. *New Zealand J. Bot.* 17: 467-508.

Armstrong, J.A. J.M. Powell & A.J. Richards (Eds) (1982). "Pollination and evolution". (Royal Bot. Gardens Trust: Sydney).

Attaway, J.A., A.P. Pieringer & L.J. Barabas (1967). The origin of *Citrus* flavour components—III. A study of the percentage variations in peel and leaf oil terpenes during one season. *Phytochemistry* 6: 25-32.

Bailey, F.M. (1883). "A synopsis of the Queensland Flora". (Govt. Printer: Brisbane).

Bailey, F.M. (1901). Labiatae. In "Queensland flora". Vol. 4, p. 1204. (Govt Printer: Brisbane).

Bailey, N.T.J. (1959). "Statistical methods in biology". (Hodder & Stoughton: London).

Ball, H.W. et al. (Eds) (1962). II. Terminology of simple symmetrical plane shapes (chart 1). *Taxon* 11: 145-156, fig. 19.

Barker, W.R. (1982). Taxonomic studies in *Euphrasia* L. (Scrophulariaceae). A revised infrageneric classification, and a revision of the genus in Australia. *J. Adelaide Bot. Gard.* 5: 1-310.

Bartling, F.G. (1830). "Ordines naturales plantarum". (Dieterich: Göttingen).

Beadle, N.C.W., O.D. Evans & R.C. Carolin (1976). "Flora of the Sydney region". (A.H. & A.W. Reed: Sydney).

Beard, J.S. (1980). A new phytogeographic map of Western Australia. *Western Austral. Herb. Res. Notes* 3: 37-58.

Bendz, G. & J. Santesson (Eds) (1973). "Chemistry in botanical classification". *Nobel Symposium 25.* (Nobel Foundation: Stockholm & Academic Press: New York).

Bentham, G. (1834). "Labiatarum genera et species". pp. 448-456. (J. Ridgeway & Sons: London).

Bentham, G. (1870). Labiatae. In "Flora Australiensis". Vo. 5, pp. 70-137. (Reeve: London).

Bentham, G. & J.D. Hooker (1876). "Genera plantarum". Vol. 2, pp. 1160-1223. (Reeve & Co.: London).

Blackall, W.E. & B.J. Grieve (1974). "How to know Western Australian wildflowers. Parts I, II, III". (Univ. Western Australia Press: [Nedlands]).

Blackburn, D.T. (1980). A generalized distance metric for the analysis of variable taxa. *Bot. Gaz.* 14: 325-335.

Bonner, J. (1950). "Plant biochemistry". (Academic Press: New York).

Briggs, B.G. & L.A.S. Johnson (1979). Evolution in the Myrtaceae—evidence from inflorescence structure. *Proc. Linn. Soc. New S. Wales* 102: 157-256.

Briquet, J. (1895). Labiatae *p.p.* in Engler, A. & K. Prantl (Eds), "Die Natürlichen Pflanzenfamilien". Teil IV, Abteilung 3a,pp. 183-221. (Engelmann: Leipzig).

Brown, R. (1810). "Prodromus Florae Novae Hollandiae". (J. Johnson & Co.: London).

Burbidge, N.T. (1955). "An index to the microfilm of Robert Brown's botanical descriptions (Manuscript) of Australian plants held by the British Museum (Natural History)". (C.S.I.R.O.: Canberra).

Burbidge, N.T. (1956). Robert Brown's Australian collecting localities. *Proc. Linn. Soc. New S. Wales* 80: 229-233.

Cain, A.J. & G.A. Harrison (1958). An analysis of the taxonomist's judgement of affinity. *Proc. Zool. Soc. London* 131: 85-98.

Cantino, P.D. (1982). Affinities of the Lamiales: A cladistic analysis. *Syst. Bot.* 7: 237-248.

Carrick, J. (1976). Studies in Australian Lamiaceae 1. Genus *Wrixonia* F. Muell. (Prostantheroideae). *J. Adelaide Bot. Gard.* 1: 27-34.

Carrick, J. (1977). Studies in Australian Lamiaceae 2. *Eichlerago* a new genus allied to *Prostanthera*. *J. Adelaide Bot. Gard.* 1: 115-122.

Cheng, Y.S. & E. von Rudloff (1970). The volatile oil of the leaves of *Chemaecyparis nootkatensis*. *Phytochemistry* 9: 2517-2527.

Churchill, D.M., T.B. Muir & D.M. Sinkora (1978). The published works of Ferdinand J.H. Mueller (1825-1896). *Muelleria* 4: 1-120.

Clifford, H.T. & W. Stephenson (1975). "An introduction to numerical classification". (Academic Press: New York).

Clifford, H.T. & W.T. Williams (1973). Classificatory dendrograms and their interpretation. *Austral. J. Bot.* 21: 151-162.

Cochrane, G.R., B.A. Fuhrer, E.R. Rotherham & J.H. Willis (1968). "Australian flora in colour. Flowers and plants of Victoria". (A.H. & A.W. Reed: Sydney).

Conn. B.J. (1980). A taxonomic revision of *Geniostoma* subg. *Geniostoma* (Loganiaceae). *Blumea* 26: 245-364.

Conn, B.J. (1982). "A taxonomic revision of *Prostanthera* Labill. section *Klanderia* (F. v. Muell.) Benth. (Labiatae)". (Unpubl. Ph. D. dissertation. Univ. of Adelaide, South Australia).

Copley, P.B. (1982). A taxonomic revision of the genus *Ixodia* (Asteraceae). *J. Adelaide Bot. Gard.* 6: 41-54.

Corner, E.J.H. (1976). "The seeds of dicotyledons". 2 vols. (Cambridge Univ. Press: Cambridge).

Cramér, H. (1946). "Mathematical methods of statistics". (Princeton Univ. Press: Princeton).

Cronquist, A. (1968). "The evolution and classification of flowering plants". (Thomas Nelson & Sons: London).

Cronquist, A. (1981). "An integrated system of flowering plants". (Columbia Univ. Press: New York).

Cunningham, G.M., W.E. Mulham, P.L. Milthorpe & J.H. Leigh (1982). "Plants of western New South Wales". (D. West, Govt Printer: Sydney).

Currey, J.E.B. (Ed.) (1966). "Reflection on the colony of New South Wales. George Caley". (Angus & Robertson: London).

Dagnelie, P. (1966). A propos des différentes méthods de classification numerique. *Rev. Statist. Appl.* 14: 55-75.

Davis, P.H. & V.H. Heywood (1963). "Principles of Angiosperm taxonomy". (Oliver & Boyd: Edinburgh).

Ehrlich, P.R. & P.H. Raven (1965). Butterflies and plants: a study in coevolution. *Evolution* 18: 586-608.

Emboden, W.A. Jr & H. Lewis (1967). Terpenes as taxonomic characters in *Salvia* section *Audibertia*. *Brittonia* 19: 152-160.

Ewart, A.J. (1930). "Flora of Victoria". (Govt Printer: [Melbourne]).

Faegri, K. & L. van der Pijl (1979). "The principles of pollination ecology". 3rd ed. (Pergamon Press: London).

Farris, J.S. (1966). Estimation of conservatism of characters by constancy within biological populations. *Evolution* 20: 587-591.

Farris, J.S. (1977). On the phenetic approach to vertebrate classification. In Hecht, M.K., B.M. Hecht & P.C. Goody (Eds), "Major patterns in Vertebrate evolution". pp. 823-850. (Plenum Press: New York).

Field, B. (Ed.) (1825). "Geographical memoirs on New South Wales; by various hands: . . . . . .". pp. 332 & 333. (John Murray: London).

Firmage, D.H. & R. Irving (1979). Effect of development on monoterpene composition of *Hedeoma drummondii*. *Phytochemistry* 18: 1827-1829.

Fisher, F.J.F. (1968). The role of geographical and ecological studies in taxonomy. In Heywood, V.H. (Ed.), "Modern methods in plant taxonomy". (Academic Press: London).

Florek, K., J. Łukaszewicz, J. Perkal, H. Steinhaus & S. Zubrzycki (1951a). Sur la liason et la division des points d'un ensemble fini. *Colloquium Math.* 2: 282-285.

Florek, K., J. Łukaszewicz, J. Perkal, H. Steinhaus & S. Zubrzycki (1951b). Taksonomia Wrocławska. *Przegl. Antropol.* 17: 193-211.

Ford, H.A. & D.C. Paton (1976). The value of insects and nectar to honeyeaters. *Emu* 76: 83 & 84.

Ford, H.A., D.C. Paton & N. Forde (1979). Birds as pollinators of Australian plants. *New Zealand J. Bot.* 17: 509-519.

Forss, D.A. & G.L. Holloway (1967). Recovery of volatile compounds from Butter oil. *J. Amer. Oil Chemists Soc.* 44: 572-575.

Fraenkel, G.S. (1959). The raison d'être of secondary plant substances. *Science* 129: 1466-1470.

Gardner, C.A. (1931). "Enumeratio plantarium Australiae occidentalis". (Govt Printer: Perth).

Gentilli, J. (1972). "Australian climate patterns". (Nelson: Melbourne).

Gottsberger, G. (1971). Colour changes of petals in *Malvaviscus arboreus* flowers. *Acta Bot. Neerl.* 20: 381-388.

Gould, S.J. & R.F. Johnston (1972). Geographic variation. *Annu. Rev. Ecol. Syst.* 3: 457-498.

Gower, J.C. (1966). Some distance properties of latent root and vector methods used in multivariate analysis. *Biometrika* 53: 325-338.

Gower, J.C. (1967). Multivariate analysis and multidimensional geometry. *Statistician* 17: 13-28.

Gower, J.C. (1969). A survey of numerical methods useful in taxonomy. *Acaralogia* 11: 357-375.

Grant, K.A. & V. Grant (1968). "Hummingbirds and their flowers". (Columbia Univ. Press: New York).

Green, J.W. (1980). A revised terminology for the spore-containing parts of anthers. *New Phytol.* 84: 401-406.

Haegi, L. (1981). Labiatae (Lamiaceae). In Jessop, J. *et al.* (Eds), "Flora of Central Australia". (*Austral. Syst. Bot. Soc.*, A.H. & A.W. Reed: Sydney).

Hagemeir, E.M. (1958). Inapplicability of the subspecies concept to North American Marten. *Syst. Zool.* 7: 1-7.

Hallé, F., R.A.A. Oldeman & P.B. Tomlinson (1978). "Tropical trees and forests. An architectural analysis". (Springer-Verlag: Berlin).

Hanover, J.W. (1966a). Environmental variation in the monoterpenes of *Pinus monticola* Dougl. *Phytochemistry* 5: 713-717.

Hanover, J.W. (1966b). Genetics of terpenes. I. Gene control of monoterpene levels in *Pinus monticola* Dougl. *Heredity* 21: 73-84.

Harborne, J.B. (Ed.) (1972). "Phytochemical ecology". (Academic Press: London).

Harborne, J.B. (1977). "Introduction to ecological biochemistry". (Academic Press: London).

Harborne, J.B. (Ed.) (1978). "Biochemical aspects of plant and animal coevolution". (Academic Press: London).

Hefendehl, F.W. & M.J. Murray (1972). Changes in monoterpene composition in *Mentha aquatica* produced by gene substitution. *Phytochemistry* 11: 189-195.

Hellyer, R.O., E.V. Lassak, H.H.G. McKern & J.L. Willis (1969). Chemical variation within *Eucalyptus dives*. *Phytochemistry* 8: 1513 & 1514.

Hickey, M. & C.J. King (1981). "100 families of flowering plants". (Cambridge Univ. Press: Cambridge).

Hill, R.S. (1980). A numerical taxonomic approach to the study of angiosperm leaves. *Bot. Gaz.* 141: 213-229.
Hill, R.S. (1981). A stopping rule for partitioning dendrograms. *Bot. Gaz.* 141: 321-324.
Hills, H.G., N.H. Williams & C.H. Dodson (1972). Floral fragrances and isolating mechanisms in the genus *Catasetum* (Orchidaceae). *Biotropica* 4: 61-76.
Hillson, C.J. (1959). Comparative studies of floral morphology of the Labiatae. *Amer. J. Bot.* 46: 451-459.
Holman, R.T. & W.H. Heimerman (1973). Identification of components of orchid fragrances by gas chromatography mass spectrometry. *Amer. Orchid Soc. Bull.* 42: 678-682.
Holmgren, P.K., W. Keuken & E.K. Schofield (1981). Index herbariorum. Part 1. The herbaria of the world, ed. 7, *Reg. Veg.* 106: 1-452.
Huck, R.B. (1981). Evolutionary patterns in *Dicerandra* (Labiatae). *Austral. Syst. Bot. Soc. Newsletter* 28: 33 & 34.
Hummel, K. & K. Staesche (1962). Die Verbreitung der Haartypen in den natürlichen Verwandtschaftsgruppen. *Handbuch der Pflanzenanatomie* Band IV, Teil 5: 207-292.
Hunt, R.S. & E. von Rudloff (1974). Chemosystematic studies in the genus *Abies*. I. Leaf and twig oil analysis of alpine and balsam firs. *Can. J. Bot.* 52: 477-487.
Hutchinson, J. (1969). "Evolution and phylogeny of flowering plants". (Academic Press: London).
Jacobs, S.W.L. & J. Pickard (1981). "Plants of New South Wales". (D. West, Govt Printer: Sydney).
Jardine, N. (1969). A logical basis for biological classification. *Syst. Zool.* 18: 37-52.
Jessop, J.P. (1980). Australian Lamiaceae. *Austral. Plants* 10 (83): 299-308.
Johns, R.K. (1961). "Geology and mineral resources of southern Eyre Peninsula". Department of Mines. Bull. 37 (Govt Printer: Adelaide).
Johnson, L.A.S. (1976). Problems of species and genera in *Eucalyptus* (Myrtaceae). *Plant Syst. Evol.* 125: 155-167.
Johnson, L.A.S. & B.G. Briggs (1975). On the Proteaceae—the evolution and classification of a southern family. *J. Linn. Soc., London, Bot.* 70: 83-182.
Johnson, R.W. (1982). Effect of weighting and the size of the attribute set in numerical classification. *Austral. J. Bot.* 30: 161-174.
Junell, S. (1934). Zur Gynäceummorphologie und Systematik der Verbenaceen und Labiaten. *Sym. Bot. Upsalienses* 4: 1-29.
Keighery, G.J. (1980). Bird pollination in south Western Australia: A checklist. *Plant Syst. Evol.* 135: 171-176.
Knoll, F. (1956). "Die Biologie der Blüte". (Springer-Verlag: Berlin).
Krumbein, W.C. (1962). The computer in geology. *Science* 136: 1087-1092.
Labillardière, J.J.H. de (1806). "Novae Hollandiae plantarum specimen". Vol. 2. (Huzard: Paris).
Lampert, R.J. (1981), "The Great Kartan mystery". (Dept. Prehistory Austral. Natl. Univ.: Canberra).
Lance, G.N. & W.T. Williams (1967). A general theory of classificatory sorting strategies. I. Hierarchical systems. *Comput. J.* 9: 373-380.
Langenheim, J.H. (1969). Amber: a botanical inquiry. *Science* 163: 1157-1169.
Langenheim, J.H. (1981). Variation in terpenoid resins: implications for insect herbivory in the tropics. In "XIII International Botanical Congress, Abstracts". (Austral. Acad. Sci.: Sydney).
Lassak, E.V. (1980). New essential oils from the Australian flora. The volatile oils of the genus *Prostanthera* (Lamiaceae) and of *Kippistia suaedifolia* (Asteraceae). (Unpubl. talk presented to 8th International Congress of Essential Oils, Cannes, 12-17 October, 1980).
Laut, P., P.C. Hegligers, G. Keig, E. Löffler, C. Margules, R.M. Scott & M.E. Sullivan (1977a). "Environments of South Australia. Province 2 Murray Mallee". (Land Use Research. C.S.I.R.O.: Canberra).
Laut, P., P.C. Hegligers, G. Keig, E. Löffler, C. Margules, R.M. Scott & M.E. Sullivan (1977b). "Environments of South Australia. Province 3 Mt Lofty Block". (Land Use Research. C.S.I.R.O.: Canberra).
Laut, P., P.C. Hegligers, G. Keig, E. Löffler, C. Margules, R.M. Scott & M.E. Sullivan (1977c). "Environments of South Australia. Province 4 Eyre and Yorke Peninsulas". (Land Use Research. C.S.I.R.O.: Canberra).
Laut, P., P.C. Hegligers, G. Keig, E. Löffler, C. Margules, R.M. Scott & M.E. Sullivan (1977d). "Environments of South Australia. Province 7 Western Pastoral". (Land Use Research. C.S.I.R.O.: Canberra).
Lawrence, G.H.M. (1955). "An introduction to plant taxonomy". (MacMillan: New York).
Leenhouts, P.W. (1968). A guide to the practice of herbarium taxonomy. *Reg. Veg.* 58: 1-60.
Leichhardt, L. (1847). "Journal of an overland expedition in Australia, . . .". (T. & W. Boone: London).
Leigh, J., J. Briggs & W. Hartley (1981). "Rare or threatened Australian plants". Austral. Natl Parks & Wildlife Serv. Special Publ. 7. (Commonwealth of Australia: [Canberra]).
Lindley, J. (1829-1830). "Edward's botanical register: or, ornamental flower-garden and shrubbery". Vol. 15 [new series vol 2], tt. 1282, 1289 [pp. 1 & 2], 1292 [pp. 2 & 3], 1300 [p. 2]. (James Ridgeway: London).
Maarse, H. & R.E. Kepner (1970). Changes in composition of volatile terpenes in Douglas fir needles during maturation. *J. Agric. & Food Chem.* 18: 1095-1101.
Marcus, L.F. & J.H. Vandermeer (1966). Regional trends in geographic variations. *Syst. Zool.* 15: 1-14.
Mayr, E. (1969). "Principles of systematic zoology". (McGraw-Hill: New York).
McGillivray, D.J. (1973). Michel Gandoger's names of Australian plants. *Contr. New S. Wales Nat. Herb.* 4: 319-365.
McNeil, J. (1978). Purposeful phenetics. *Syst. Zool.* 28: 465-482.
McQuinn, W.G. (1970). "Allan Cunningham. Botanist and explorer". (Melbourne Univ. Press: Carlton).
Meissner, L.P. & E.I. Organick (1980). "Fortran 77: featuring structured programming". (Addison-Wesley: Reading, Massachusetts).

Melchior, H. (1964). Labiatae. In "A. Engler's Syllabus der Pflanzenfamilien". Ed. 12 vol. 2, pp. 438-444. (Borntraeger: Berlin).

Mitchell, T.L. (1848). "Journal of an expedition into the interior of tropical Australia, . . .". (Longman, Brown, Green & Longmans: London).

Moore, C. (1893). Labiatae. In "Handbook of the Flora of New South Wales". (C. Potter, Govt Printer: Sydney).

Mueller, F. [J.H. von] (1855). Definition of rare or hitherto undescribed Australian plants, chiefly collected within the boundaries of the colony of Victoria. *Trans. Phil. Soc. Victoria* 1: 48.

Mueller, F. [J.H. von] (1868). Fragmenta phytographie Australiae. Vol. 6, p. 108. Melbourne.

Mueller, F. [J.H.] von (1875). Fragmenta phytographie Australiae. Vol. 9, p. 162. Melbourne.

Mueller, F. [J.H.] von (1882). "Systematic Census of Australian plants". (M'Carron, Bird & Co. for Victorian Govt: Melbourne).

Muller, C.H. (1966). The role of chemical inhibition (allelopathy) in vegetation composition. *Bull. Torrey Bot. Club* 9: 332-351.

Munir, A.A. (1978). Taxonomic revision of Chloanthaceae trib. Physopsideae. *Brunonia* 1: 407-692.

Munir, A.A. (1979). Taxonomic revision of genus *Pityrodia* (Chloanthaceae). *J. Adelaide Bot. Gard.* 2: 1-138.

Nelson, E.C. (1981). Phytogeography of southern Australia. In Keast, A. (Ed.), "Ecological Biogeography of Australia". (W. Junk bv: The Hague).

Nicholas, H.J. (1973). Terpenes. In Miller, L.P. (Ed.), "Phytochemistry. Volume II Organic metabolites". pp. 254-309. (Van Nostrand Reinhold: New York), pp. 254-309.

Nie, N.H., C.H. Hull, J.C. Jenkins, K. Steinbrenner & D.H. Bent (1975). "Statistical Package for Social Sciences". 2nd ed. (McGraw-Hill Book Co.: New York).

Oh, H.K., T. Sakai, M.B. Jones & W.M. Longhurst (1967). Effects of various essential oils located from Douglas fir needles upon sheep and deer rumen microbial activity. *Appl. Microbiol.* 15: 777-784.

Paton, D.C. & H.A. Ford (1977). Pollination by birds of native plants in South Australia. *Emu* 77: 73-85.

Penfold, A.R. & J.L. Willis (1961). "The Eucalypts". World Crop Series (Leonard Hill: London, & Interscience Publ.: New York).

Pijl, L. van der (1972). Functional considerations and observations on the flowers of some Labiatae. *Blumea* 20: 93-103.

Porter, D.M., R.W. Kiger & J.E. Monahan (1973). "A guide for contributors to the flora of North America. Part II. An outline and glossary of terms for morphological and habitat description (provisional ed.)". (Smithsonian Institution: Washington, D.C.).

Powell, R.A. & R.P. Adams (1973). Seasonal variation in the volatile terpenoids of *Juniperus scopulorum* (Cupressaceae). *Amer. J. Bot.* 60: 1041-1050.

Pridham, J.B. (Ed.) (1967). "Terpenoids in plants". (Academic Press: New York).

Proctor, M. & P. Yeo (1973). "The pollination of flowers". (Collins: London).

Pyke, G.H. (1980). The foraging behaviour of Australian honeyeaters: a review and some comparisons with hummingbirds. *Austral. J. Ecol.* 5: 343-369.

Ratkowsky, D.A. & G.N. Lance (1978). A criterion for determining the number of groups in a classification. *Austral. Comput. J.* 10: 115-117.

Raven, P.H. (1972). Why are bird-visited flowers predominately red? *Evolution* 26: 674.

Raven, P.H. (1974). Nomenclature proposals to the Leningrad congress. I. Proposals for the simplification of infraspecific terminology. *Taxon* 23: 828-831.

Reichenbach, H.G.L. (1828). "Conspectus regni vegetabilis". (Cnobloch: Leipzig).

Roth, I. (1977). Fruits of Angiosperms. *Handbuch der Pflanzenanatomie* Band X, Teil 1: 1-675.

Rudloff, E. von (1967). Chemosystematic studies in the genus *Picea* (Pinaceae). I. Introduction. *Can. J. Bot.* 45: 891-901.

Rudloff, E. von (1972a). Chemosystematic studies in the genus *Pseudotsuga*. I. Leaf oil analysis of the coastal and Rocky Mountain varieties of the Douglas fir. *Can. J. Bot.* 50: 1025-1040.

Rudloff, E. von (1972b). Seasonal variation in the composition of the volatile oil of the leaves, buds, and twigs of white spruce (*Picea glauca*). *Can. J. Bot.* 50: 1595-1603.

Rudloff, E. von (1973). Geographical variation in the terpene composition of the leaf oil of Douglas fir. *Pure & Applied Chem.* 34: 401-410.

Rudloff, E. von (1975). Volatile leaf oil analysis in chemosystematic studies of North American conifers. *Biochem. Syst. Ecol.* 2: 131-167.

Runeckles, V.C. & T.J. Mabry (Eds) (1973). "Terpenoids. Structure, biogenetics and distribution". (Academic Press: New York).

Sandermann, H. (1962). Terpenoids: Structure and distribution. In Florkin, M. & O.H.S. Mason (Eds), "Comparative biochemistry, Volume III". pp. 503-630. (Academic Press: New York).

Sandland, R.L. & P.C. Young (1979). Probabilistic tests and stopping rules associated with heirarchial classification techniques. *Austral. J. Ecol.* 4: 399-406.

Schmid, R. (1972). A resolution of the *Eugenia-Syzygium* controversy (Myrtaceae). *Amer. J. Bot.* 59: 423-436.

Schodde, R., B. Glover, F.C. Kinsky, S. Marchant, A.R. McGill & S.A. Parher (1978). Recommended English names for Australian birds. *Emu* Suppl. 77: 245-307.

Sharma, M. & V. Singh (1982). Morphology of the gynoecium in Labiatae. *Blumea* 28: 61-75.

Smith, P.M. (1976). "The chemotaxonomy of plants". (Edward Arnold: London).

Sneath, P.H.A. (1957). The application of computers to taxonomy. *J. Gen. Microbiol.* 17: 201-226.
Sneath, P.H.A. (1964). Mathematics and classification from Adanson to the present. In Lawrence, G.H. (Ed.), "Adanson: The bicentennial of Michael Adanson's "Familles de Plantes"". pp. 471-498. (Univ. of Pittsburgh Press: Pittsburgh).
Sneath, P.H.A. & R.R. Sokal (1973). "Numerical taxonomy". (W.H. Freeman: San Francisco).
Sokal, R.R. (1965). Statistical methods in systematics. *Biol. Rev.* 40: 337-391.
Sokal, R.R. & R.C. Rinkel (1963). Geographic variation of the alate *Phemphigua populi-transverus* in eastern North America. *Univ. Kansas Sci. Bull.* 44: 467-507.
Sokal, R.R. & F.J. Rohlf (1969). "Biometry". (W.H. Freeman: San Francisco).
Sokal, R.R. & P.H.A. Sneath (1963). "Principles of numerical taxonomy". (W.H. Freeman: San Francisco).
Sondheimen, E. & J.B. Simeone (1970). "Chemical ecology". (Academic Pres: New York).
Southwell, I.A. (1973). Variation in the leaf oil of *Eucalyptus punctata. Phytochemistry* 12: 1341-1343.
Specht, R.L. (1972). "The vegetation of South Australia". (Govt Printer: Adelaide).
Stace, H.C.T., C.D. Hubble, R. Brewer, K.H. Northcote, J.R. Sleeman, M.J. Mulcahy & E.G. Hallsworth (1968). "A handbook of Australian soils". (Rellim Tech. Publ.: Glenside, South Australia).
Stafleu, F.A. & R.S. Cowan (1976). Taxonomic literature. 2nd ed. Vol. I: A-G. *Reg. Veg.* 94: 1-1136.
Stafleu, F.A. & R.S. Cowan (1979). Taxonomic literature. 2nd ed. Vol. II: H-Le. *Reg. Veg.* 98: 1-991.
Stafleu, F.A. & R.S. Cowan (1981). Taxonomic literature. 2nd ed. Vol. III: Lh-O. *Reg. Veg.* 105: 1-980.
Stafleu, F.A. *et al.* (Eds) (1978). International code of botanical nomenclature. *Reg. Veg.* 97.
Stearn, W.T. (1960). Introduction to R. Brown's 'Prodromus Florae Novae Hollandiae'. In Brown R. "Prodromus Florae Novae Hollandiae et Insulae Van Diemen (1810) and Supplement Primum (1830)". pp. vlii. Facsimile ed. (Engelmann: Weinheim).
Stearn, W.T. (1973). "Botanical latin". 2nd ed. (David & Charles: Newton Abbott, Great Britain).
Stephenson, W., W.T. Williams & S. Cook (1974). The macrobenthos of soft bottoms in southern Moreton Bay (south of Peel Island). *Mem. Queensl. Mus.* 17: 73-124.
Stopp, K. (1950a). Karpologische Studien I & II. *Abh. Akad. Wiss. Lit. Mainz, Math.-Nat. Kl.* 7: 165-218.
Stopp, K. (1950b). Karpologische Studien III & IV. *Abh. Akad. Wiss. Lit. Mainz, Math.-Nat. Kl.* 17: 495-542.
Thien, L.B., W.H. Heimermann & R.T. Holman (1975). Floral odors and quantitative taxonomy of *Magnolia* and *Liriodendron. Taxon* 24: 557-568.
Thorne, R.F. (1976). A phylogenetic classification of the Angiospermae. In Hecht, M.K., W.C. Steere & B. Wallace (Eds), *Evolutionary Biol.* 9: 35-106.
Toelken, H.R. (1981). The species of *Crassula* L. in Australia. *J. Adelaide Bot. Gard.* 3: 57-90.
Troll, W. (1964). "Die Infloreszenzen. Typologie und Stellung im Aufbau des Vegetationskörpers, 1. I Deskriptive Morphologie des Infloreszenzen; II Typologie der Infloreszenzen". (Jena: Gustav Fischer).
Troll, W. (1969). "Die Infloreszenzen. Typologie und Stellung im Aufbau des Vegetationskörpers, 2. III Monotele Synfloreszenzen". (Jena: Gustav Fischer).
Turner, B.L. (1970). Molecular approaches to population problems at the infraspecific level. In Harborne, J.B. (Ed.), "Phytochemical phylogeny". pp. 187-205. (Academic Press: New York).
Tutin, T.G., V.H. Heywood, N.A. Burges, D.H. Valentine, S.M. Walters & D.A. Webb (1964). Introduction. In "Flora Europaea". Vol. 1, p. xx. (Cambridge Univ. Press: Cambridge).
Twidale, C.R. (1968). "Geomorphology". (Nelson: Melbourne).
Uphof, J.C. Th. (1962). Plant hairs. *Handbuch der Pflanzenanatomie* Band IV, Teil 5: 1-206.
Weberling, F. (1965). Typology of inflorescences. *J. Linn. Soc.* (*Bot.*) 59: 215-221.
Weberling, F. (1981). "Morphologie der Blüten und der Blütenstande". (Eugeu Ulmer: Stuttgart).
Weberling, F. (1982). Current problems of modern inflorescence morphology. In Conn, B.J. (Ed.), "Inflorescence morphology". *Austral. Syst. Bot. Soc. Newsletter* 30: 5-21.
Weimarck, G. (1972). On "Numerical chemotaxonomy". *Taxon* 21: 615-619.
Whiffin, T. (1977). Volatile oils and the study of natural hybridization between *Correa aemula* and *C. reflexa* (Rutaceae). *Austral. J. Bot.* 25: 291-298.
Whiffin, T. (1978). Geographic variation in tropical tree species. In Tomlinson, P.B. & M.H. Zimmermann (Eds), "Tropical trees as living systems". pp. 31-54. (Cambridge Univ. Press: Massachusetts).
Whiffin, T. (1981). Analysis of hybridization between *Eucalyptus pauciflora* Sieber ex Spreng. and *E. radiata* Sieber ex DC (Myrtaceae). *Bot. J. Linn. Soc.* 83: 237-250.
Whiffin, T. (1982a). Variation and evolution in the genus *Flindersia* (Rutaceae). II Review of methods for geographic variation analysis of volatile oil data. *Austral. J. Bot.* 30: 645-657.
Whiffin, T. (1982b). Numerical analysis of volatile oil data in systematic studies of Australian rainforest trees. *Taxon* 31: 204-210.
White, C.T. (1944). Contribution to the Queensland flora, No. 8. *Proc. Roy. Soc. Queensl.* 55: 74.
Williams, W.T. (1971). Principles of clustering. *Annu. Rev. Ecol. Syst.* 2: 303-326.
Williams, W.T. (Ed.) (1976). "Pattern analysis in agricultural sciences". (C.S.I.R.O. Elsevier: Amsterdam).
Williams, W.T., M.B. Dale & G.N. Lance (1971). Two outstanding ordination problems. *Austral. J. Bot.* 19: 251-258.
Williams, W.T. & P. Gillard (1971). Pattern analysis of a grazing experiment. *Austral. J. Agric. Res.* 22: 245-260.
Williams, W.T. & W. Stephenson (1973). The analysis of three-dimensional data (sites x species x time) in marine ecology. *J. Exp. Mar. Biol. Ecol.* 11: 207-227.

Willis, J.H. (1973). "A handbook to plants in Victoria. Volume II Dicotyledons". (Melbourne Univ. Press: Carlton).

Winkler, H. (1939). Versuch eines "naturlich" Systems der Früchte. *Bietr. Biol. Pflanzen* 26: 201-220.

Winkler, H. (1940). Zur Einigung und Weiterführung in der Frage des Fruchtsystems. *Beitr. Biol. Pflanzen* 27: 92-130.

Wojciechowska, B. (1958). Taxonomy, morphology and anatomy of fruits and seeds in the genus *Salvia* L. *Monographiae Botanicae* 6: 3-56.

Wojciechowska, B. (1961a). Fruits of the middle european species of the genus *Prunella* L. (fam. Labiatae), their morphology and anatomy. *Monographiae Botanicae* 12: 49-88.

Wojciechowska, B. (1961b). Fruits of the middle european species of the subfamily Stachyoideae (fam. Labiatae). *Monographiae Botanicae* 12: 89-120.

Wojciechowska, B. (1966). Morphologie und Anatomie der Früchte und Samen aus der Familie der Labiatae mit besonderer Berücksichtigung der Arzneipflanzen. *Monographiae Botanicae* 21: 3-244.

Womble, W.H. (1951). Differential systematics. *Science* 114: 315-322.

Zavarin, E., W.B. Critchfield & K. Snajberk (1969). Turpentine composition of *Pinus contorta* x *Pinus banksiana* hybrids and hybrid derivatives. *Can. J. Bot.* 47: 1443-1453.

Zavarin, E., L. Lawrence & M.C. Thomas (1971). Compositional variation of leaf monoterpenes in *Cupressus macrocarpa, C. pygmaea, C. goveniana, C. abramsiana* and *C. sargentii. Phytochemistry* 10: 379-393.

Zavarin, E. & K. Snajberk (1973). Geographic variability of monoterpenes from cortex of *Pseudotsuga menziesii. Pure & Applied Chem.* 34: 411-434.

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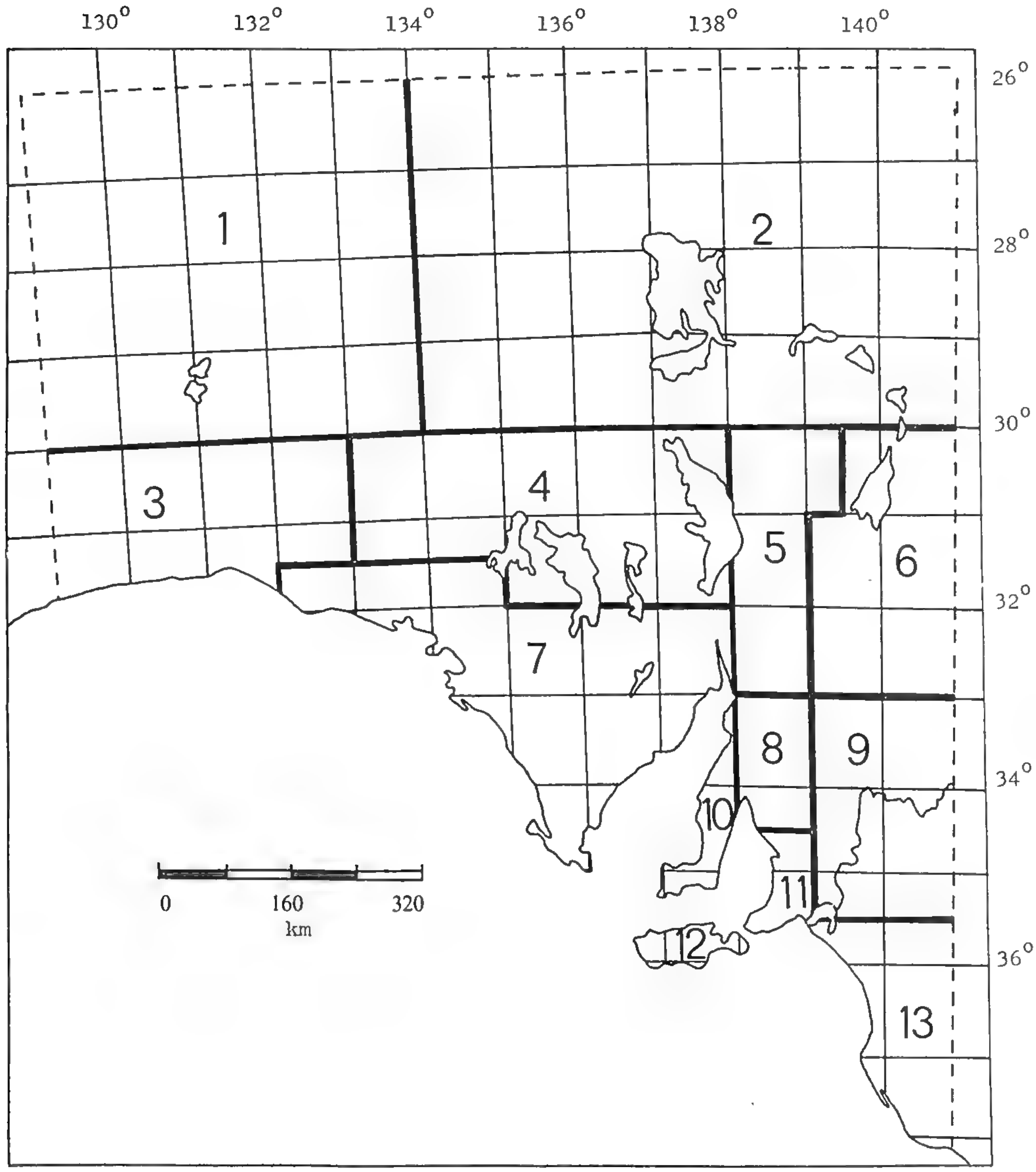
REGIONS OF SOUTH AUSTRALIA ADOPTED BY THE STATE HERBARIUM — ADELAIDE

1. North-western
2. Lake Eyre Basin
3. Nullarbor
4. Gairdner-Torrens Basin
5. Flinders Ranges
6. Eastern
7. Eyre Peninsula
8. Northern Lofty
9. Murray
10. Yorke Peninsula
11. Southern Lofty
12. Kangaroo Island
13. South-eastern



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